Building Electrification Presentation 10.20.22

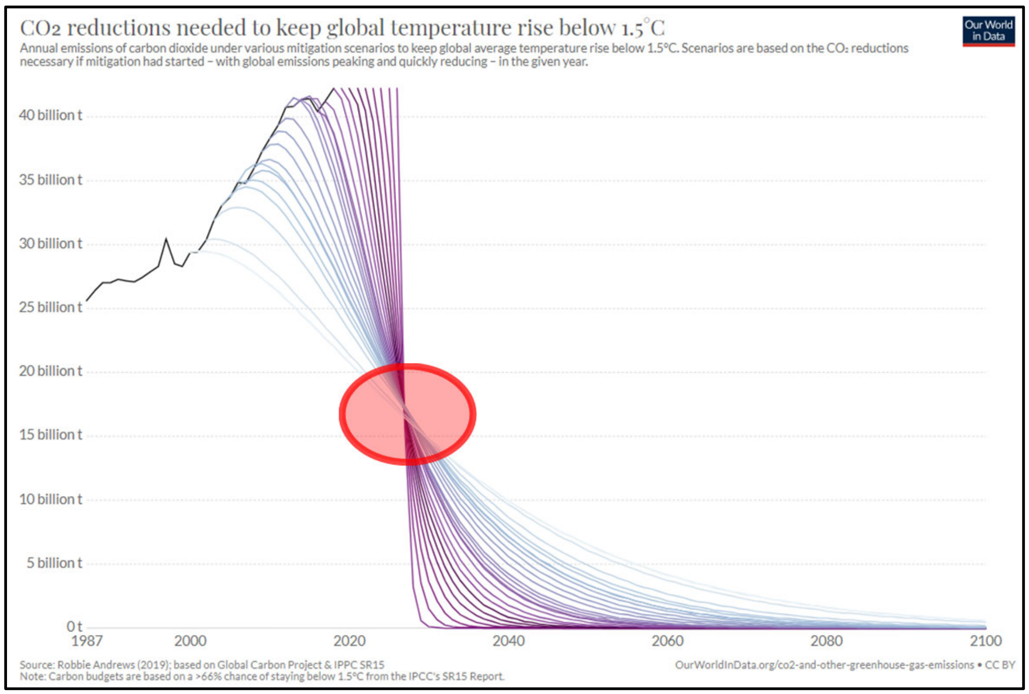
Matthew Kavanagh

Green Insight

Start with **Why** - Climate Change requires Everyone's Action Today

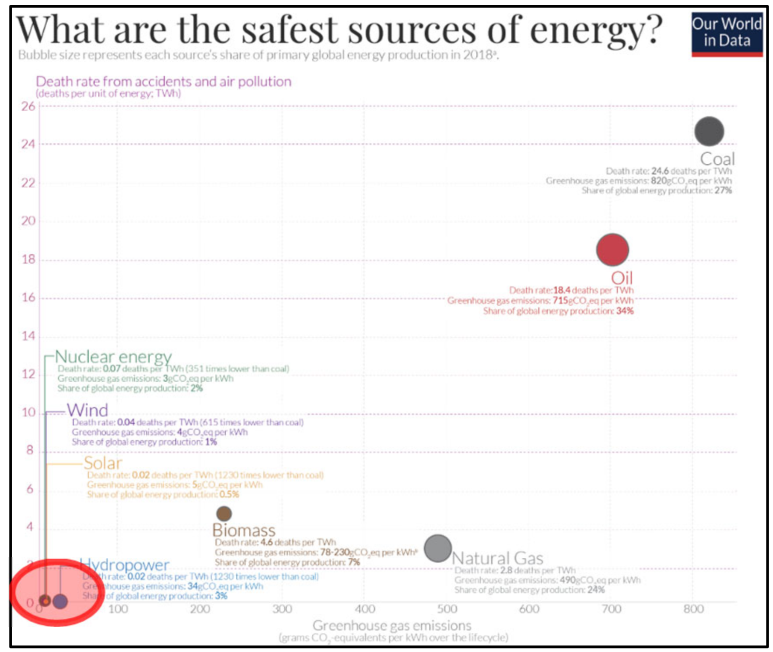
Green Insight

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 sunshine = 1 Yr of human electric)
4. **Requires very little water**
5. **Affords energy freedom and resiliency**



Start with Why - Climate Change requires Everyone's Action Today

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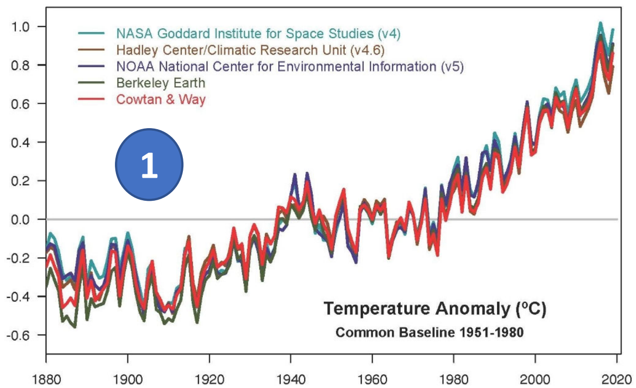
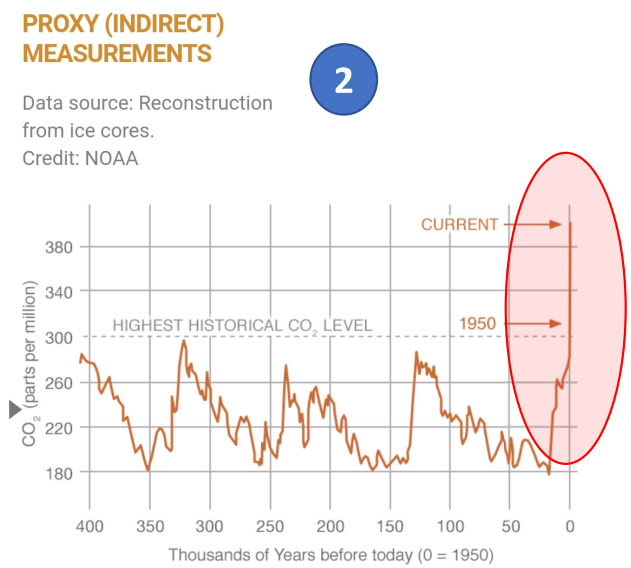
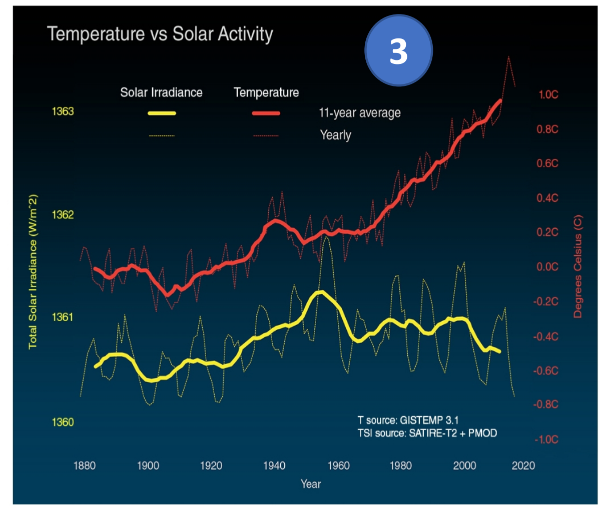


Temperature data showing rapid warming in the past few decades. According to NASA data, 2016 was the warmest year since 1880, continuing a long-term trend of rising global temperatures. The 10 warmest years in the 140-year record all have occurred since 2000, with the six warmest years being the six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





1. Global mean temperatures continue to raise year over year (NASA) *(*NJ is higher than average*)*
2. Atmospheric CO_2 is above >400 ppm (up from 280 ppm 1850s) (NOAA)
3. Anthropogenic green house gas emissions are the cause (not solar activity) (IPCC)

Residential Case Study

1. **Kavanagh Energy Transformation and Decarbonization Plan (New Jersey)**

Kavanagh – Energy and Carbon Footprint Transformation (4 year plan)

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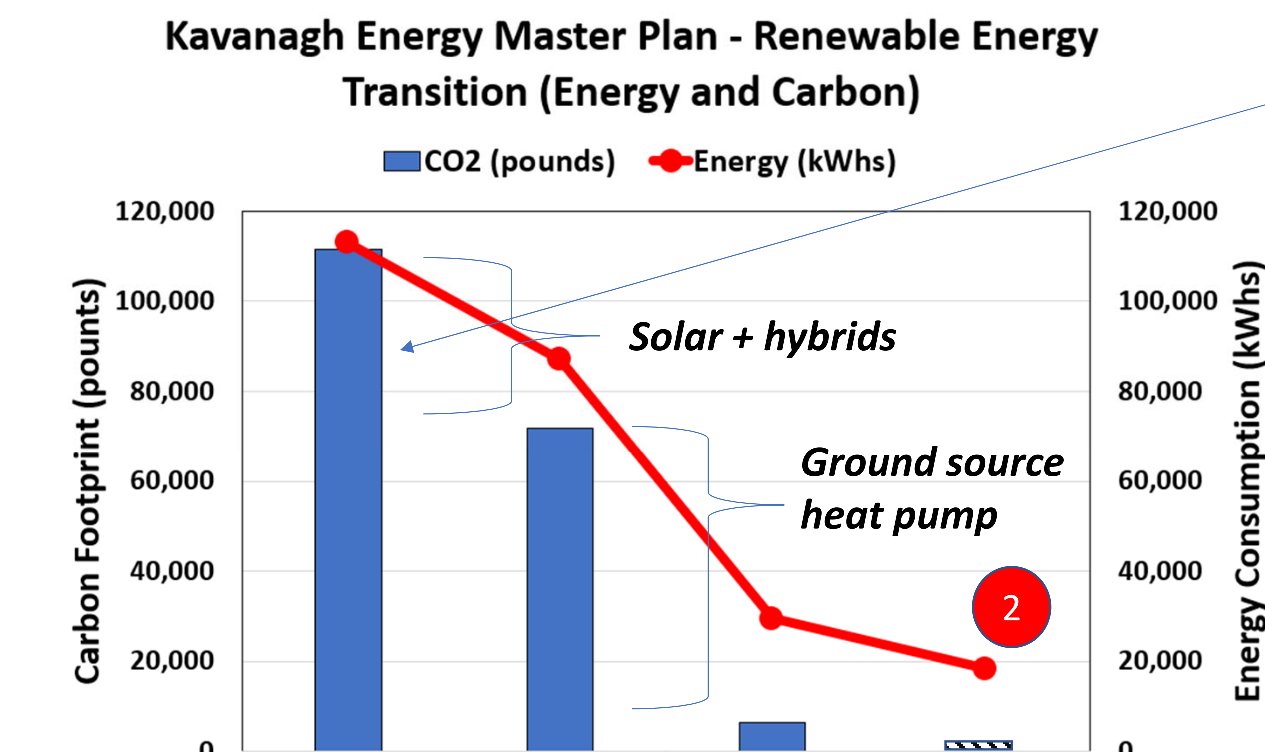


	2018	2019	2020	2021
CO_2 (pounds)	111,642	71,719	6,481	0 (1)
Energy (kWhs)	113,047	87,098	29,454	18,333

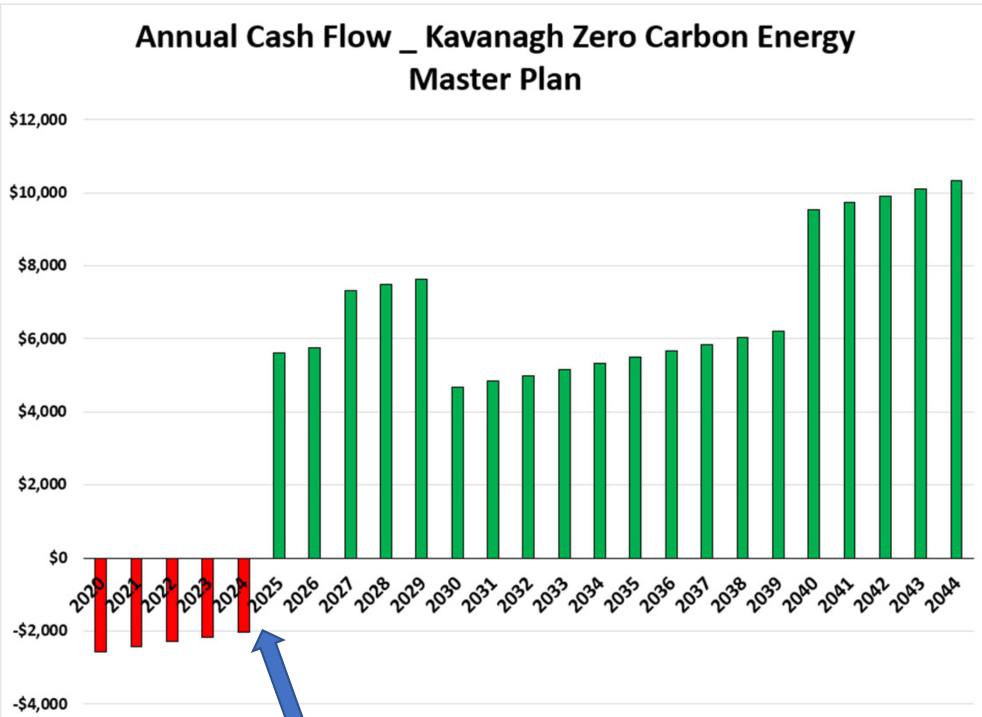
*Includes electric, heating/cooling, transportation (gas) and lawn care energy demands (*electric lawncare).*

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

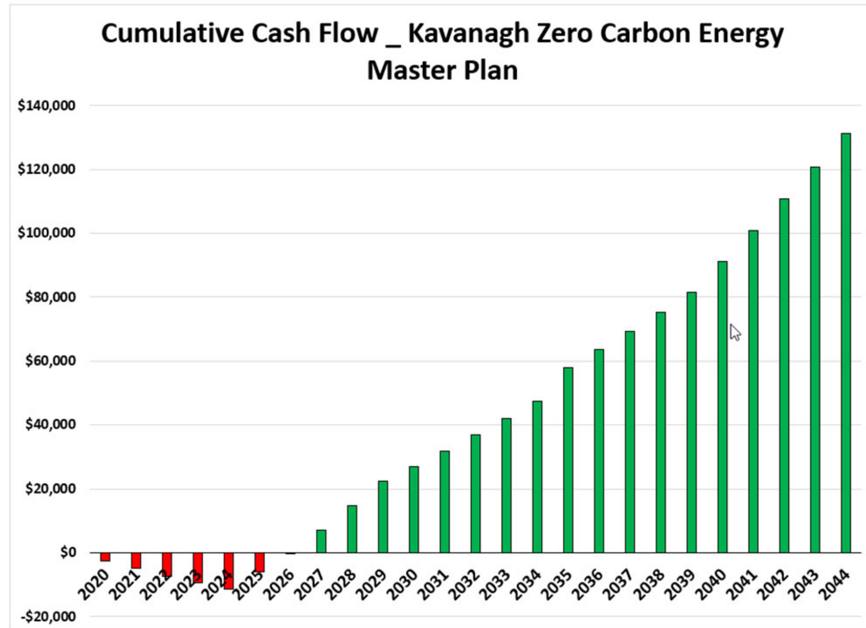
*gas offsets

2 **>80% <u>gross</u> energy consumption reduction (*converted to kWhs)**

Kavanagh 25 Year Cash Flows for Renewable Transition



Positive Cash Flow after 5.5 years

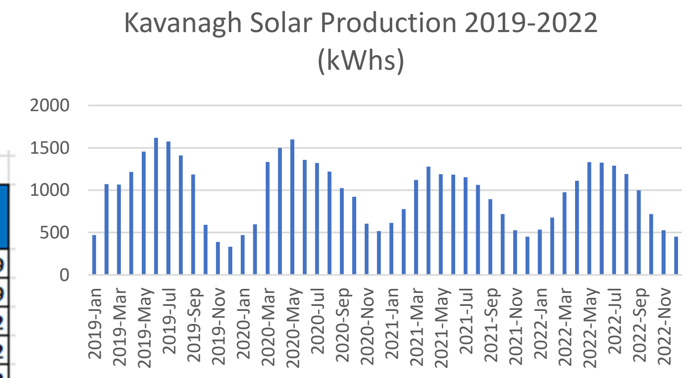


- $135k positive cash flow (25 year) – 154% ROI (~6% Annual ROI)
- ~$25k additional rebates
- More savings beyond warranty & ground loop lifespan (50-100 years)

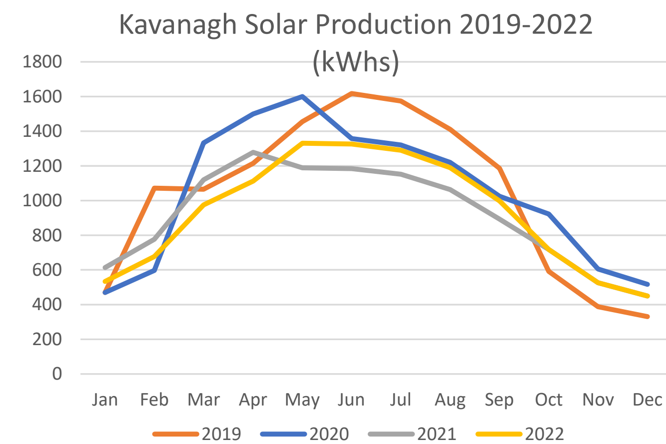
Renewable Cash Flow Data

	ANNUAL COSTS W/O RE		ANNUAL COSTS With RE		CUMMULATIVE CASH FLOW		
	Annual	Cummulative	Annual	Cummulative	Annual Savings	Cummulative	Carbon Savings (lbs)
2020	$ 6,417	$ 6,417	$ 8,977	$ 8,977	(2,560)	(2,560)	96,519
2021	$ 6,545	$ 12,962	$ 8,977	$ 17,954	(2,432)	(4,992)	96,519
2022	$ 6,676	$ 19,639	$ 8,977	$ 26,931	(2,301)	(7,292)	111,642
2023	$ 6,810	$ 26,448	$ 8,977	$ 35,908	(2,167)	(9,460)	111,642
2024	$ 6,946	$ 33,394	$ 8,977	$ 44,885	(2,031)	(11,491)	111,642
2025	$ 7,085	$ 40,479	$ 1,477	$ 46,362	5,608	(5,883)	111,642
2026	$ 7,227	$ 47,706	$ 1,477	$ 47,839	5,750	(133)	111,642
2027	$ 7,371	$ 55,077	$ 37	$ 47,876	7,334	7,201	111,642
2028	$ 7,519	$ 62,595	$ 37	$ 47,913	7,482	14,682	111,642
2029	$ 7,669	$ 70,264	$ 37	$ 47,950	7,632	22,314	111,642
2030	$ 7,822	$ 78,087	$ 3,137	$ 51,087	4,685	27,000	111,642
2031	$ 7,979	$ 86,065	$ 3,137	$ 54,224	4,842	31,841	111,642
2032	$ 8,138	$ 94,204	$ 3,137	$ 57,361	5,001	36,843	111,642
2033	$ 8,301	$ 102,505	$ 3,137	$ 60,498	5,164	42,007	111,642
2034	$ 8,467	$ 110,972	$ 3,137	$ 63,635	5,330	47,337	111,642
2035	$ 8,636	$ 124,608	$ 3,137	$ 66,772	5,499	57,836	111,642
2036	$ 8,809	$ 133,417	$ 3,137	$ 69,909	5,672	63,508	111,642
2037	$ 8,985	$ 142,403	$ 3,137	$ 73,046	5,848	69,357	111,642
2038	$ 9,165	$ 151,568	$ 3,137	$ 76,183	6,028	75,385	111,642
2039	$ 9,348	$ 160,916	$ 3,137	$ 79,320	6,211	81,596	111,642
2040	$ 9,535	$ 170,452	$ -	$ 79,320	9,535	91,132	111,642
2041	$ 9,726	$ 180,178	$ -	$ 79,320	9,726	100,858	111,642
2042	$ 9,921	$ 190,098	$ -	$ 79,320	9,921	110,778	111,642
2043	$ 10,119	$ 200,217	$ -	$ 79,320	10,119	120,897	111,642
2044	$ 10,321	$ 210,538	$ -	$ 79,320	10,321	131,218	111,642
	$ 205,538		$ 79,320		Lbs CO2	Pound CO2	2,760,802
				$ 131,218	Tons CO2	Tons CO2	1,380

$131 k in net cash



Positive cash by year 5.5



1,400 Tons of lifetime carbon savings

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Kavanagh Solar Production vs Usage (Electric)

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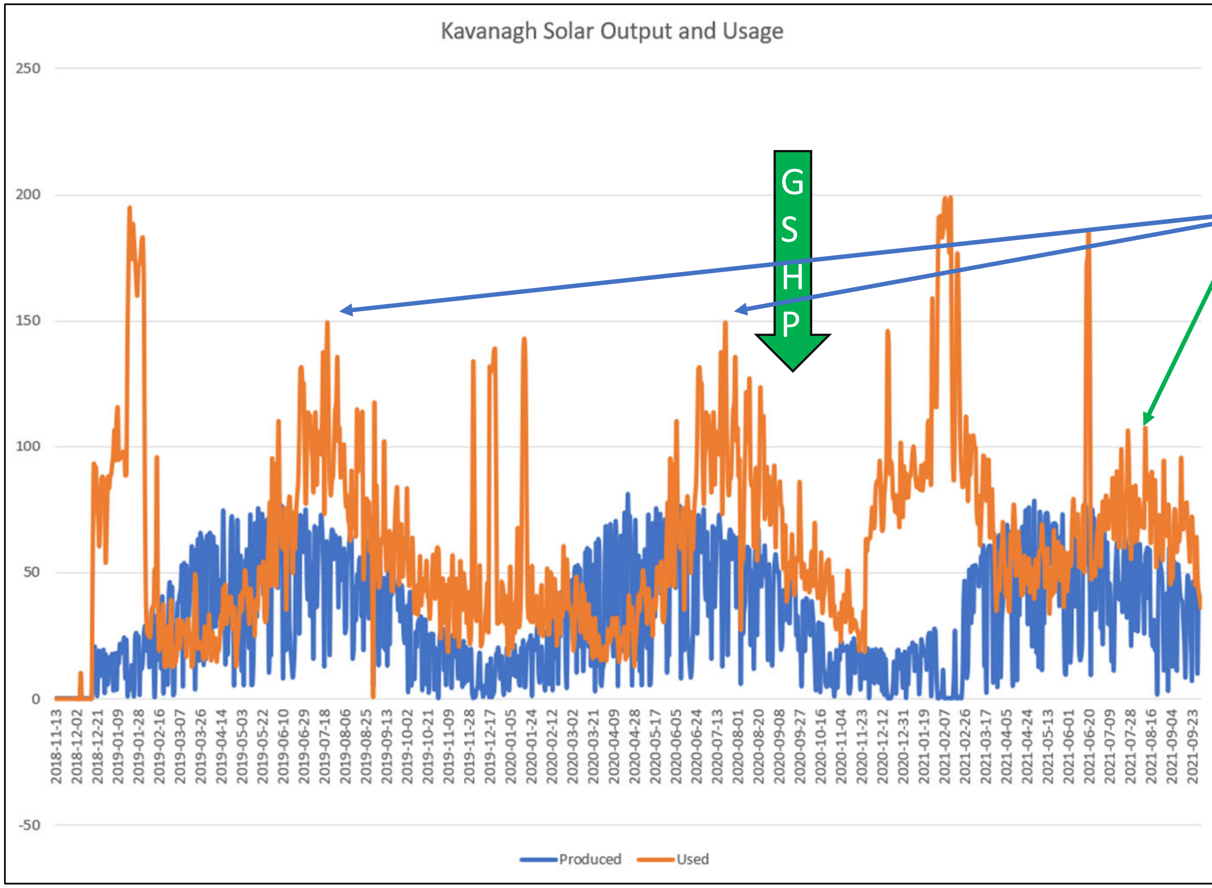

- Summer peak electric demands lower after Geothermal installed
- Peak solar output ~75kWh/day in June/July
- December lowest solar output ~20kWh/day
- Spring usually has a surplus (lower energy usage and higher solar production)
- Natural Gas bill drops to 1-2 Therms ~$12/month for gas cooktop

Bill History + Expand All Bil

	Total Consumption:	Total Therms:	Total Gas Charges:
09/22/2022	1	1.0594	12.33
08/23/2022	1	1.0586	12.32
07/26/2022	1	1.0582	12.32
06/24/2022	0	0.0000	11.00
05/25/2022	2	2.1162	13.65
04/26/2022	1	1.0580	12.32
03/25/2022	1	1.0587	12.33
02/24/2022	1	1.0592	12.33
01/25/2022	1	1.0611	12.33
12/23/2021	2	2.1224	13.17
11/22/2021	1	1.0641	11.27
10/22/2021	2	2.1280	12.42

Ground Source Heat Pump – What is it?

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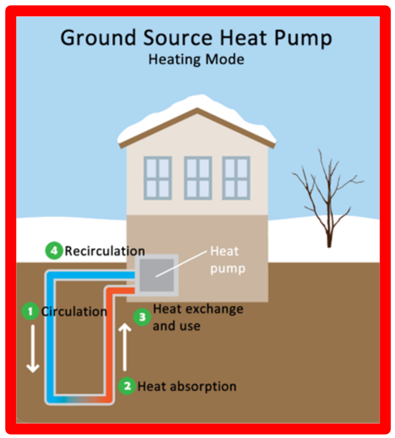
- A geothermal heat pump (GHP) or ground source heat pump (GSHP) is a central heating and/or cooling system that transfers heat to or from the ground, often through a vapor-compression refrigeration cycle. Commercial and residential applications. [1]
- Also known as a "geoexchange, earth-coupled, or 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]

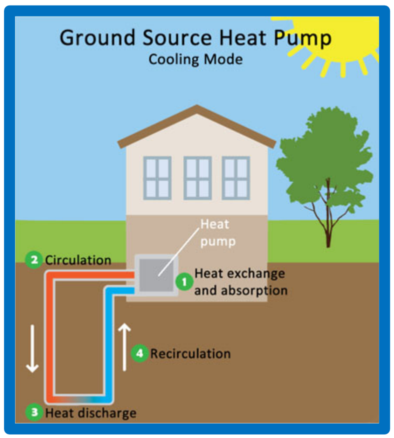
Heating Mode – Extracting heat

1



Cooling Mode – Moving heat to the ground

2



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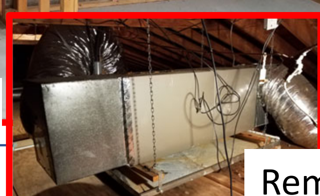
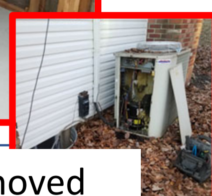
Our Install (2020)

- **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

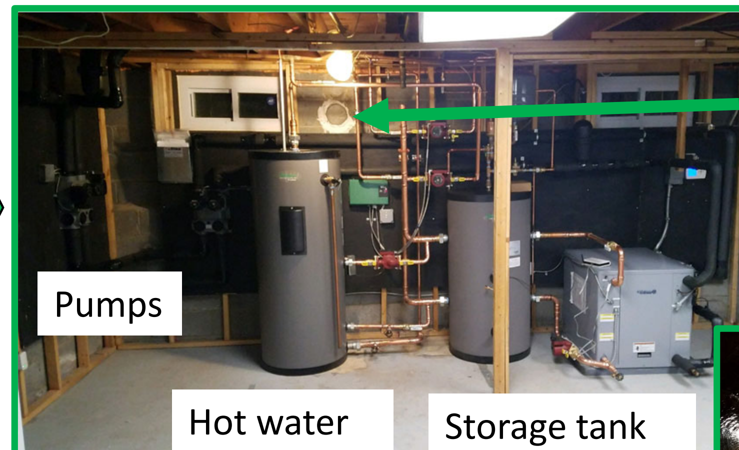

Before (natural gas furnace and hot water heater)

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

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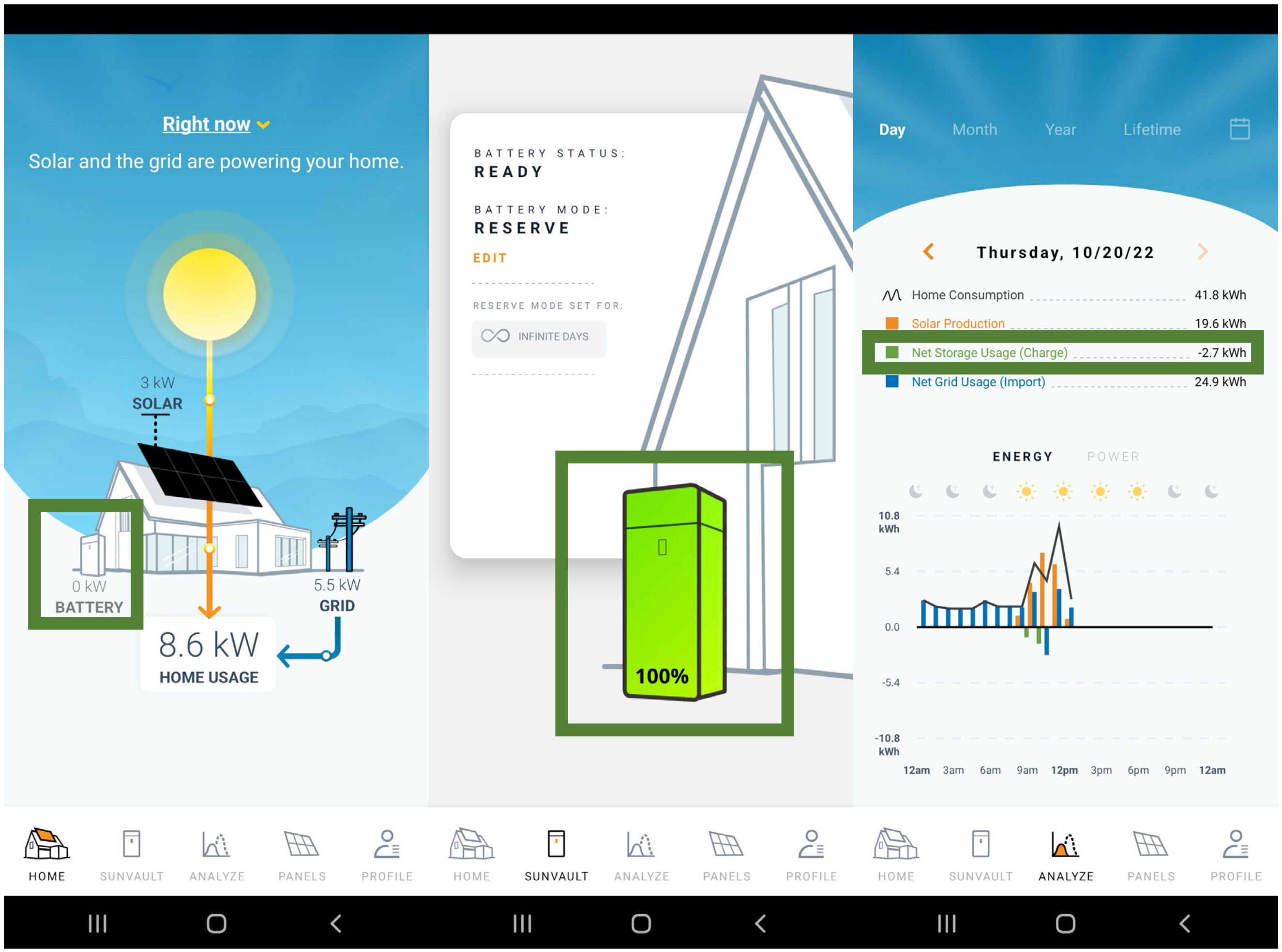

- 2022 installed 52-kilowatt hour energy storage system
- Whole house back up in event of outage
- Pairs with solar system and recharges during the day
- Indefinite back up at reduced load
- 10 year warranty on battery capacity

[Mega SunVault™ Storage Install – YouTube]

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

Volt Plug in Hybrid Savings Analysis

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#/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

Electric Costs	$ 358	Gas Costs Saved	$ 937
Electric Cost/Mile	$ 0.052	Gas Costs / Mile	$ 0.136

Net Savings
$ 580

Estimated Total kWhs Full Electric 3674

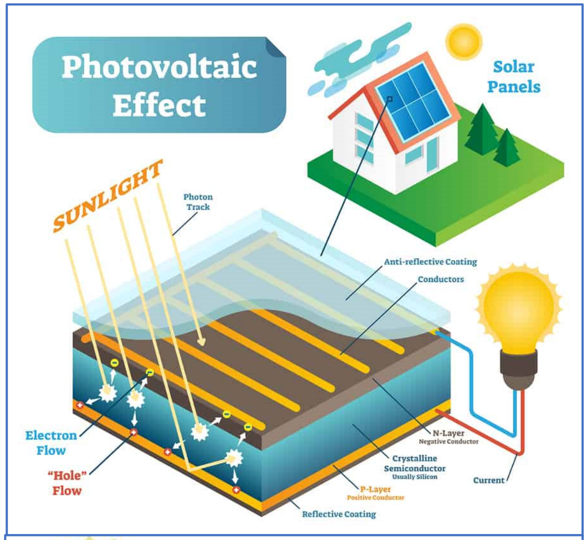
Cost per mile is 3X lower for EVs - **~$750 savings / yr** + maintenance savings

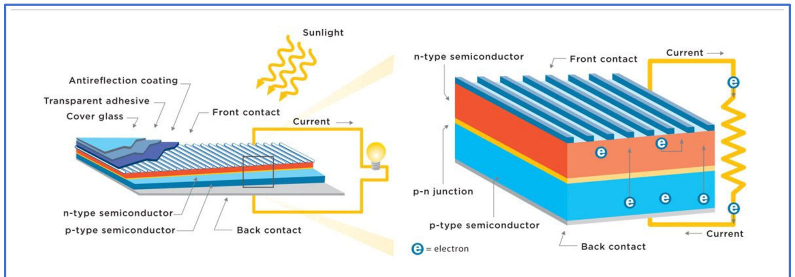
Savings even higher with increasing gas prices

APPENDIX

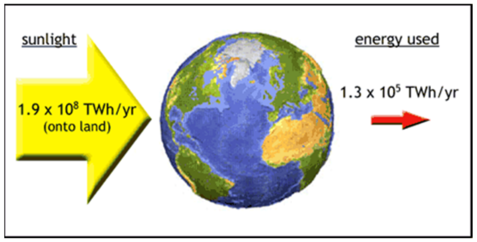
How Does Solar Works - Science

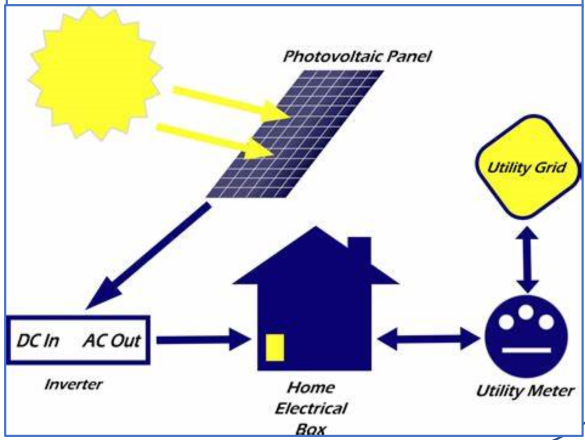
1. Photos of light hit the solar cells or PV material and dislodge electrons which creates a voltage across the gap (~0.5V).
2. Multiple cells create a voltage per PV module, and these are strung together like lights to form "strings".
3. Each string produces power and current which is then converted 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.

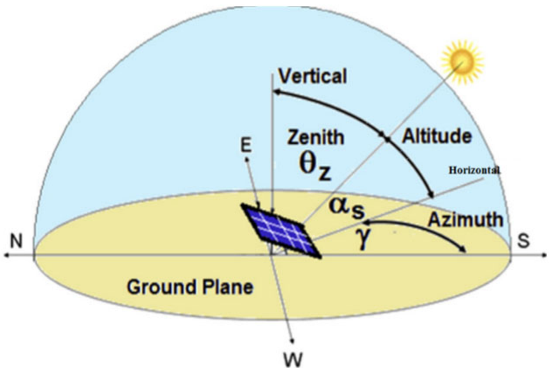




How Does Solar Work – Performance Factors

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)

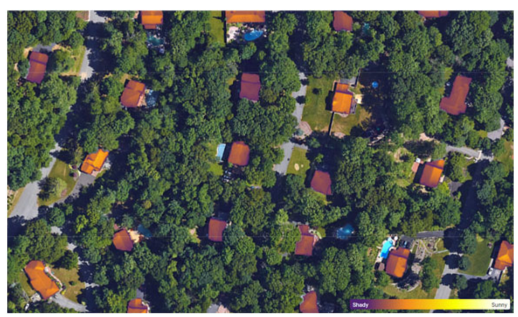
Orientation Chart showing output for different orientation and tilt angles (% of maximum)

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

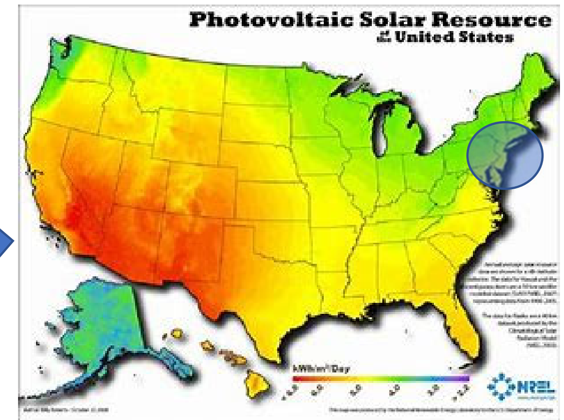
Source: PVNI.org.uk

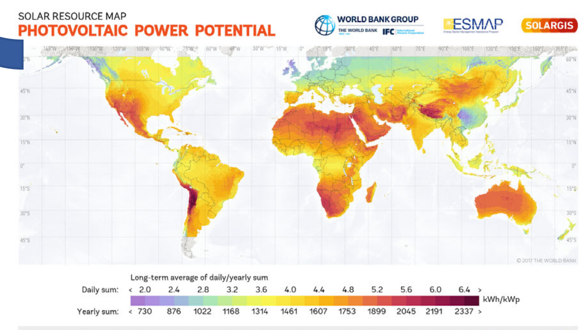
2) Shade (no/low shade is best)

Project Sunroof (google.com)



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

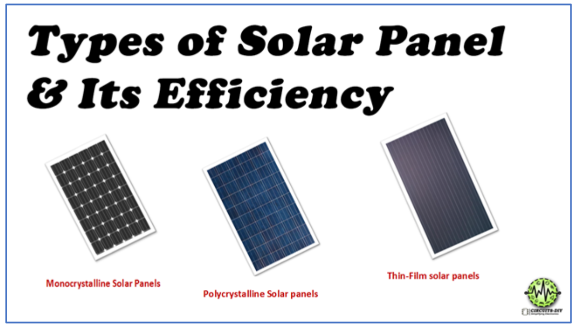


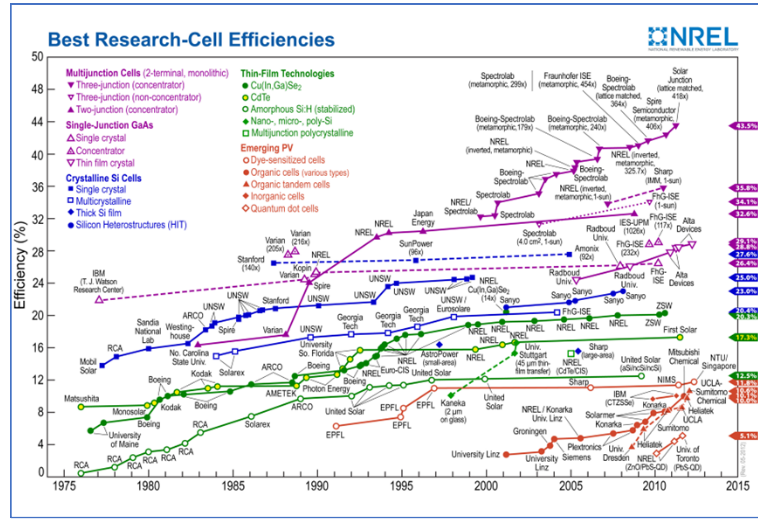


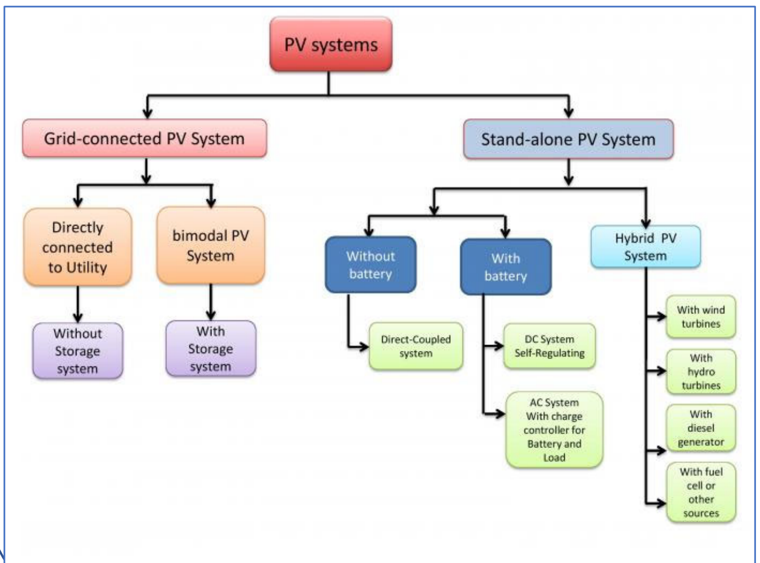
Types of Solar

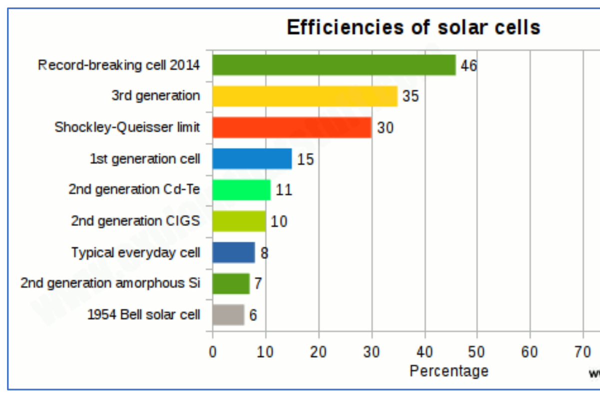
PV Types (efficiencies vary & efficiency matters)

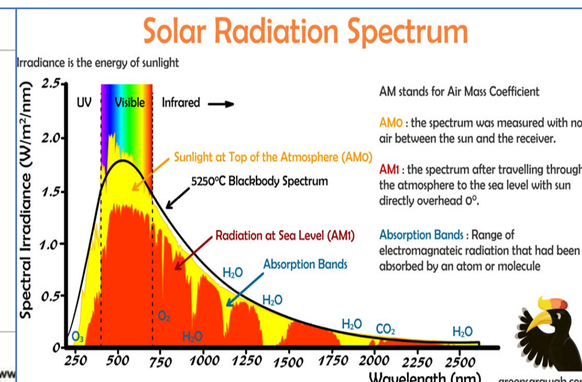
Systems:
(grid connected, stand alone)





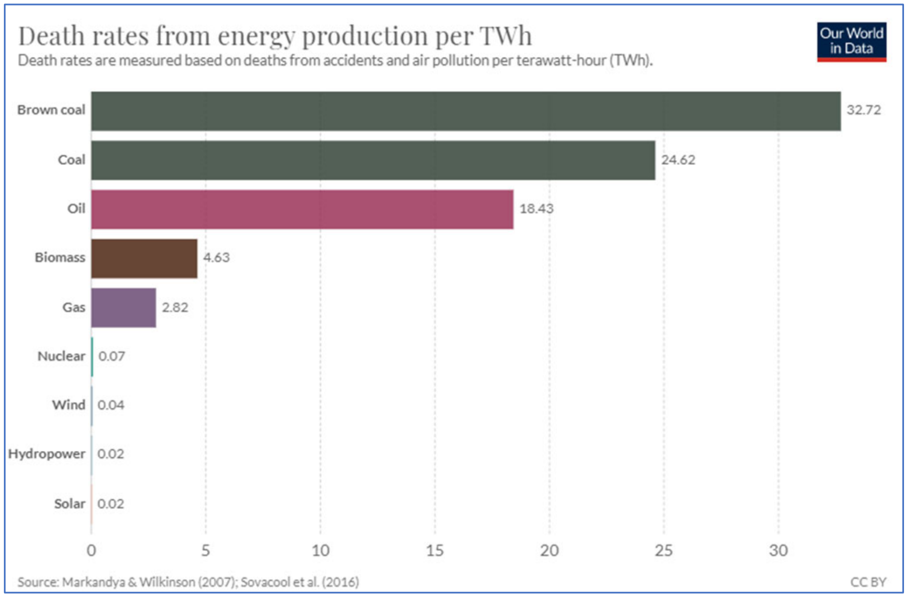


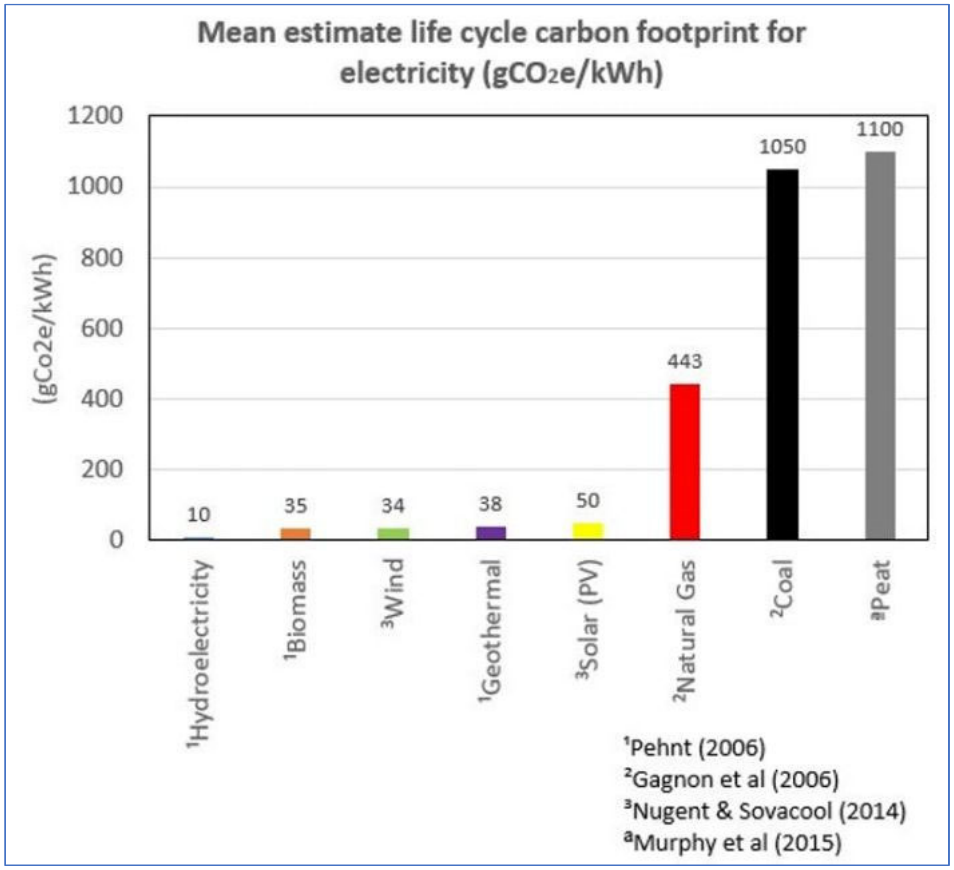




Benefits of Solar – Clean / Safe

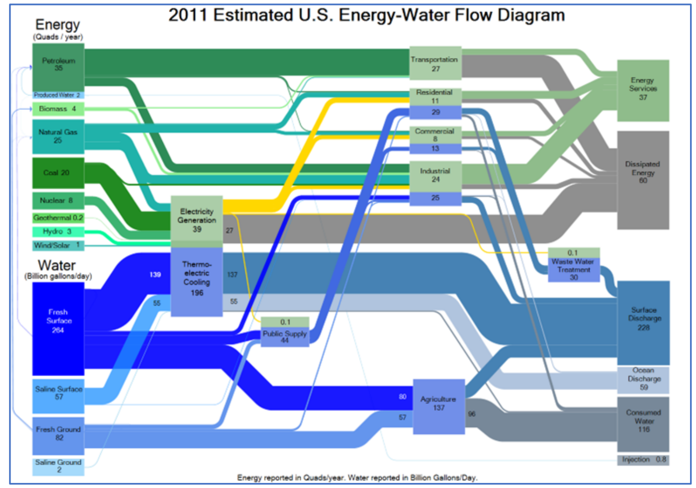
- Carbon savings due to not burring fossil fuels and due to reduced supply chains
- Reduced societal impacts comparted to the alternate

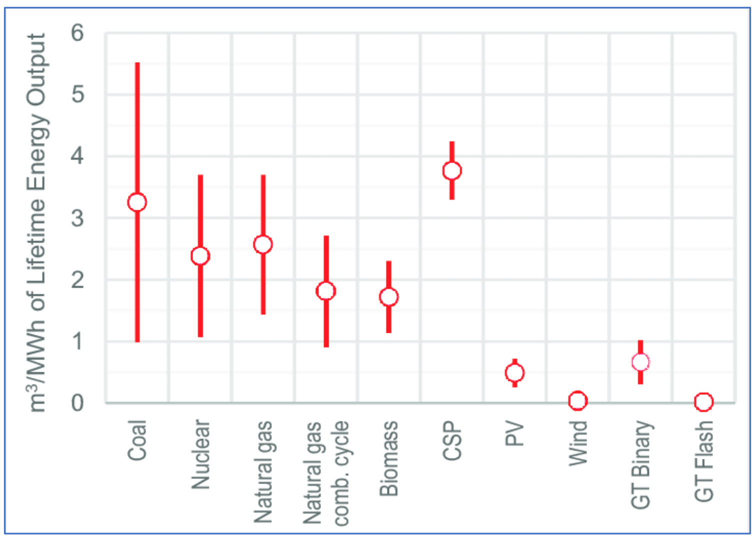


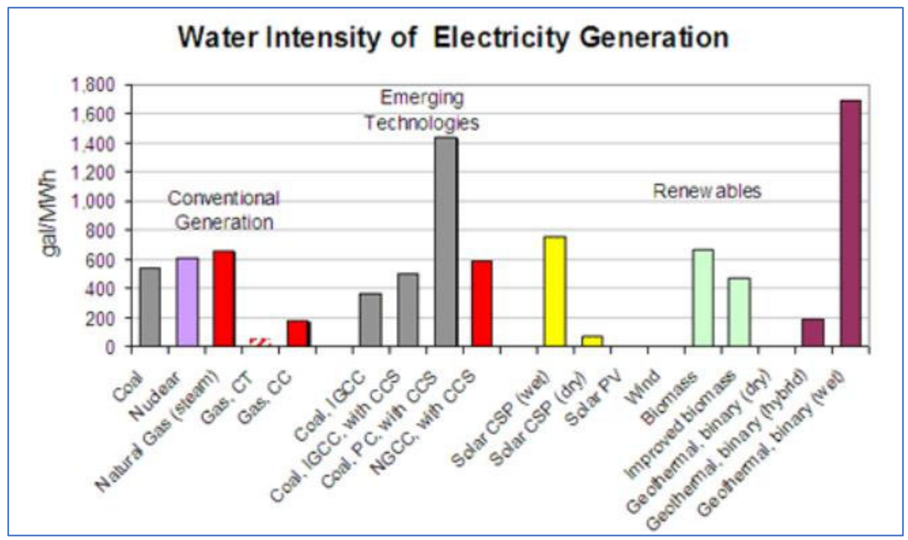


Benefits of Solar – Low Water Usage

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

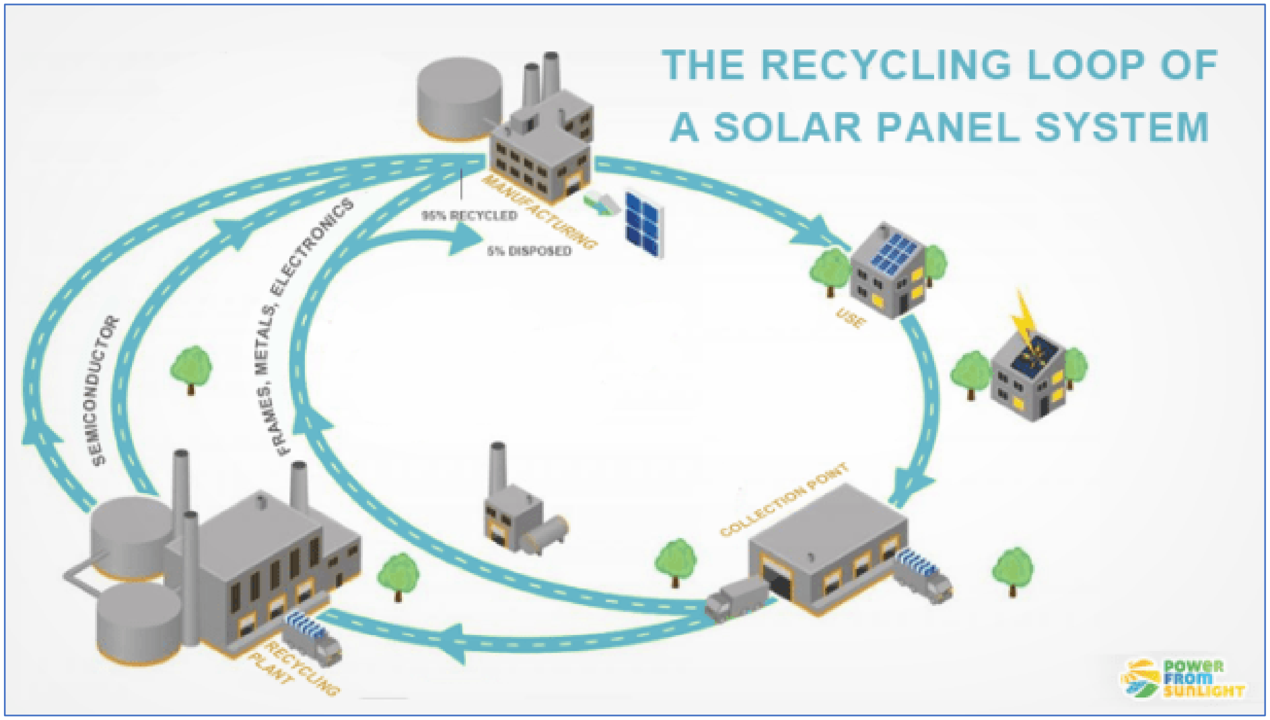






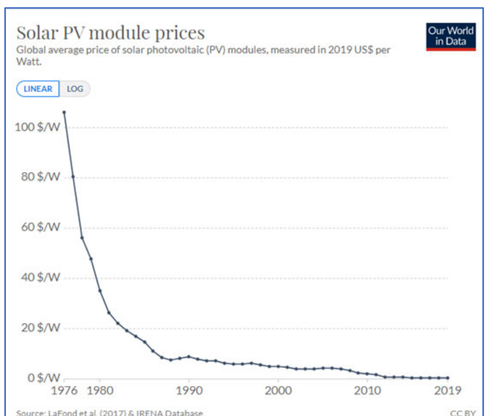
Benefits of Solar – Circular / Sustainable

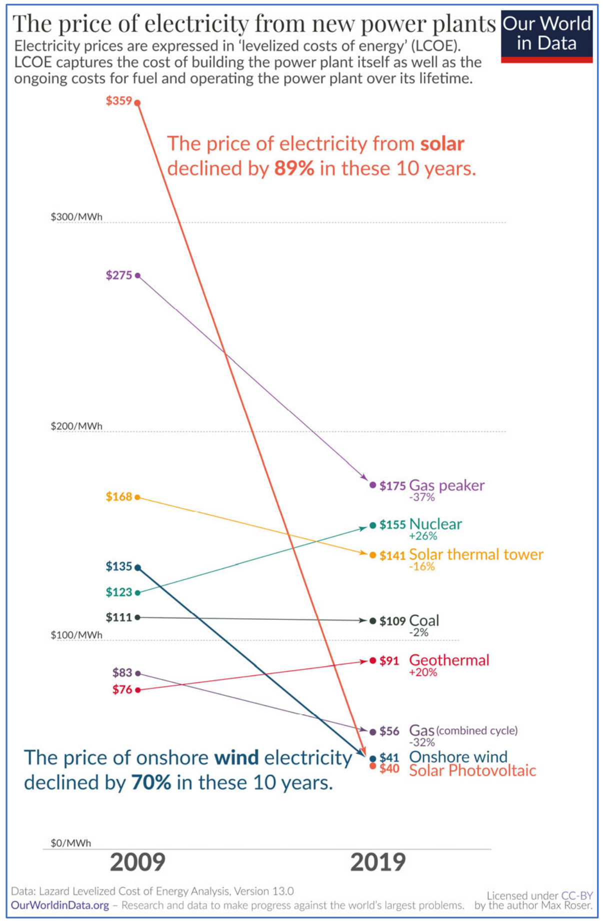
- Solar modules can be recycled
- Mostly glass and aluminum
- 95-98% recyclable
- More innovation to come
- You can't recycle fossil fuels

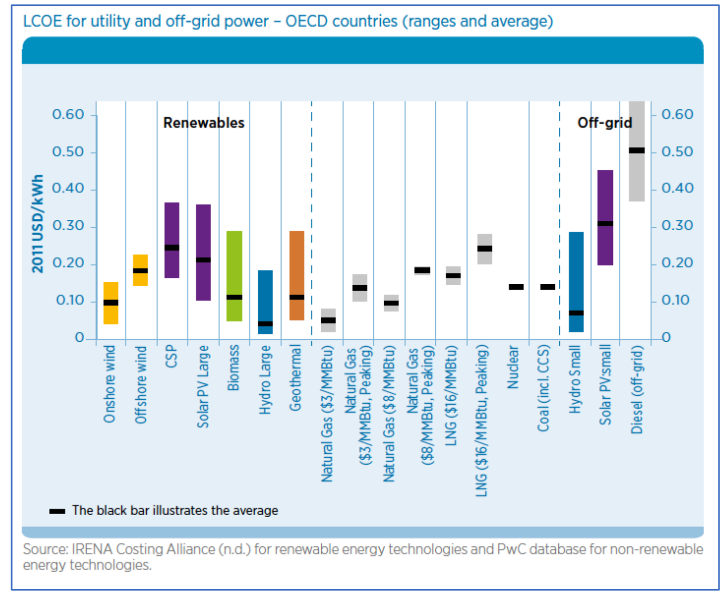


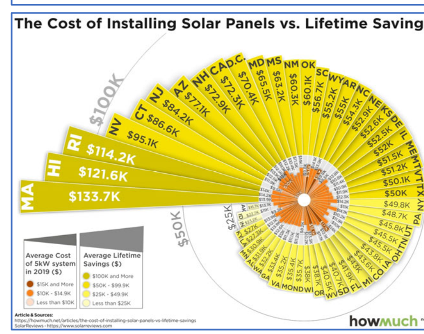
Benefits of Solar – Cheap (now)

- 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





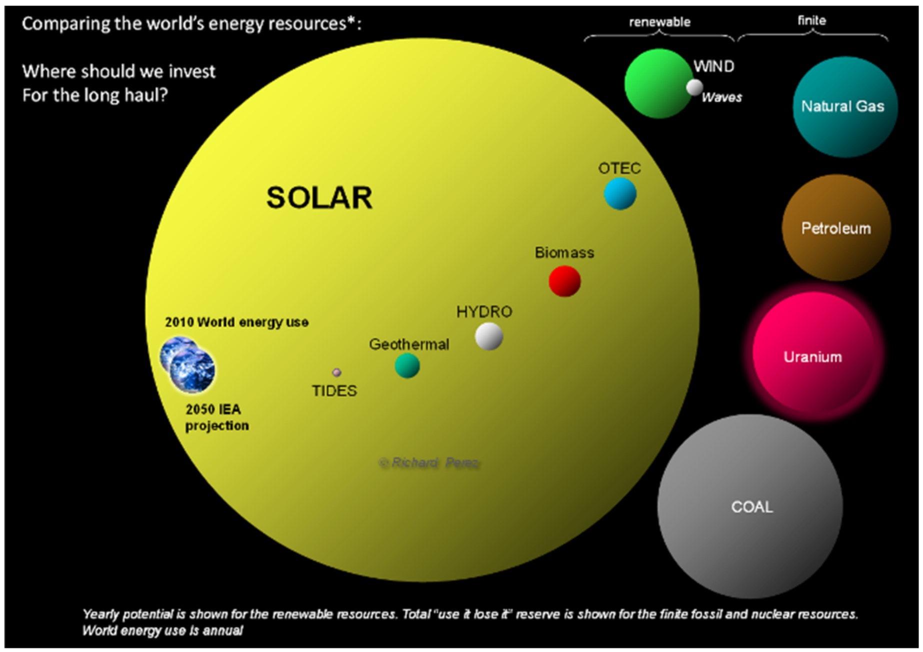




Green Insight

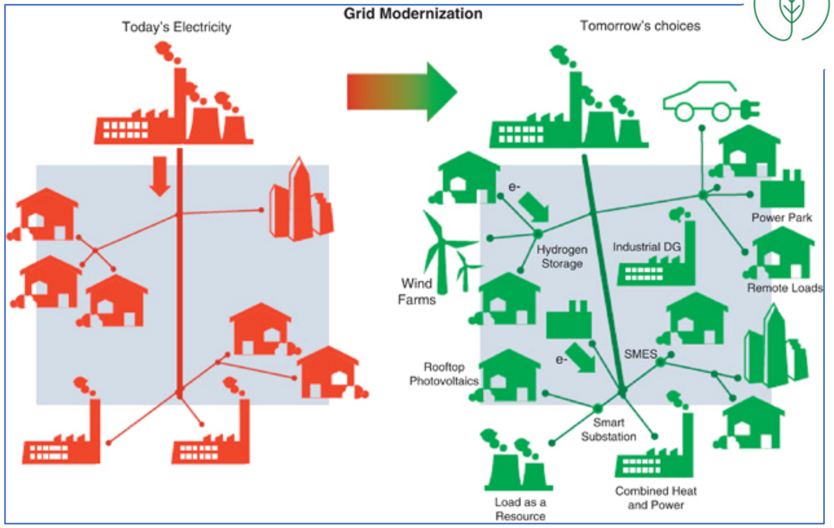
Benefits of Solar – Abundant

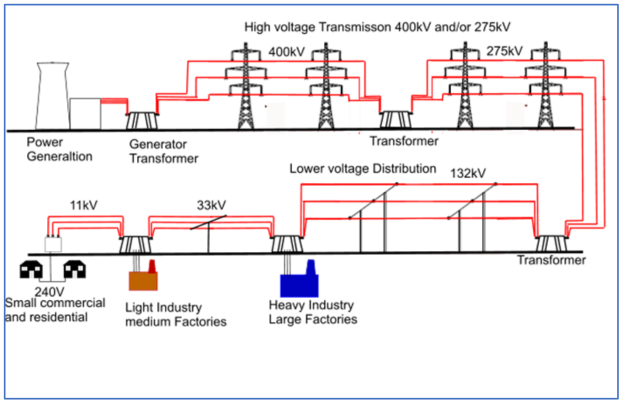
- The sun is the most abundant resource we have
- The sun is available almost anywhere
- No fuel supply chains required (eg coal, natural gas)
- 1 hour of sun could power humanity for a year

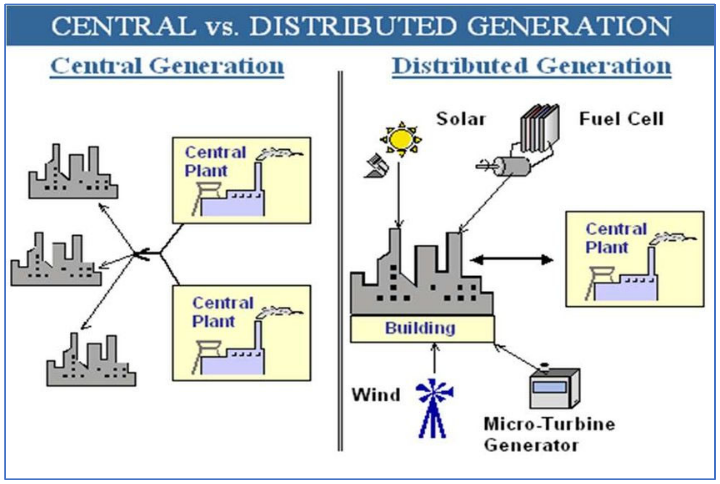


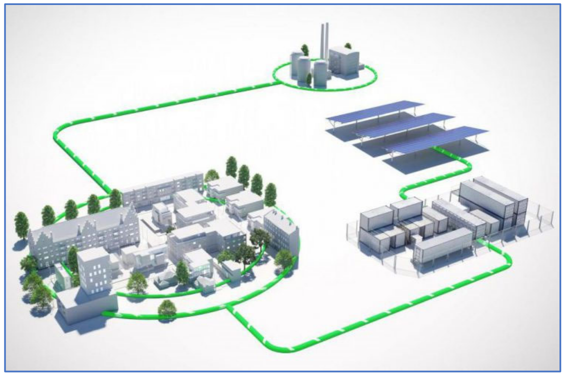
Benefits of Solar – Distributed

- 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



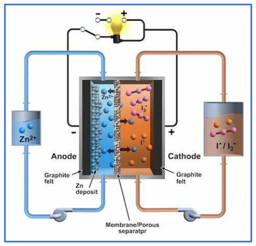


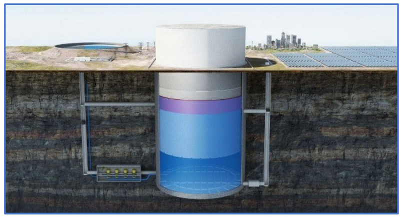


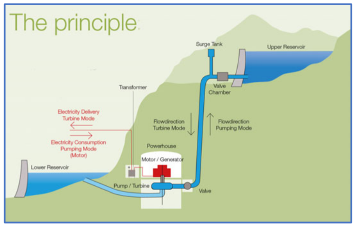


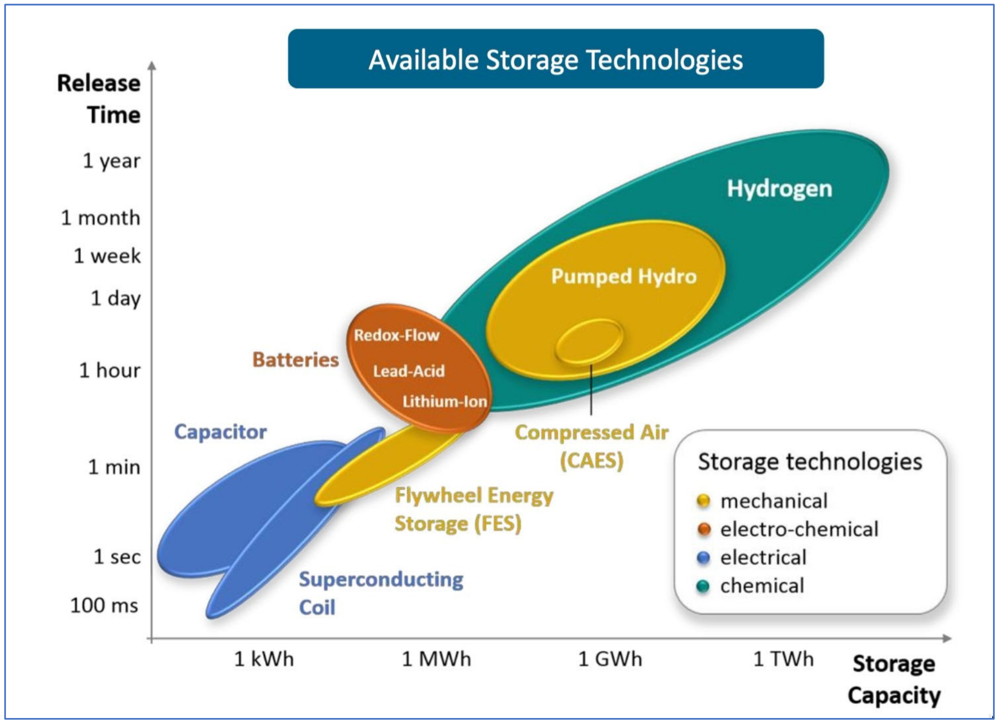
Renewable Energy Storage Systems

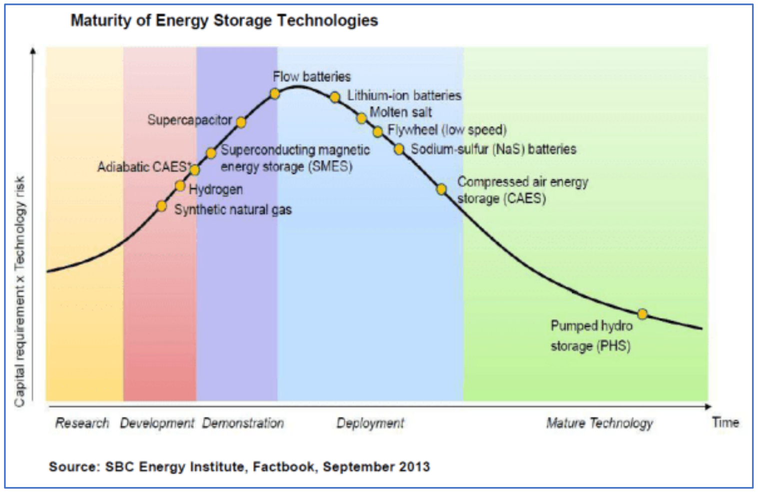
- Intermittency problem - when the sun doesn't shine, we still need energy. Solution = store it for later.
- Incredible spectrum of energy storage options
- (electrical, mechanical, chemical, gravity)





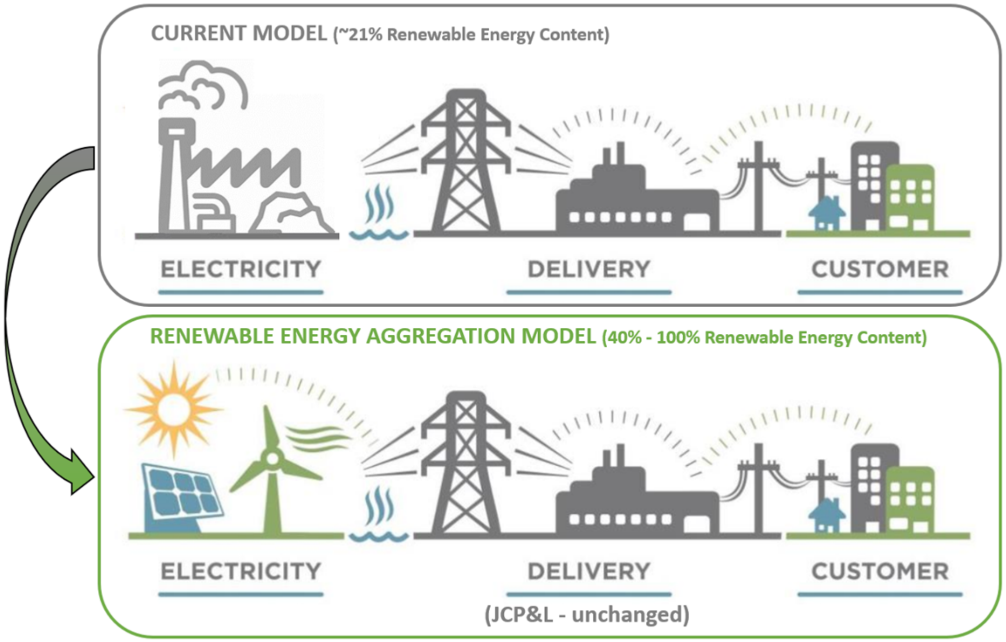






3rd Party Clean Energy Providers

- 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

Green Insight

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
- 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 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]

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]

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

Renewable Cash Flow Data & Carbon Impact

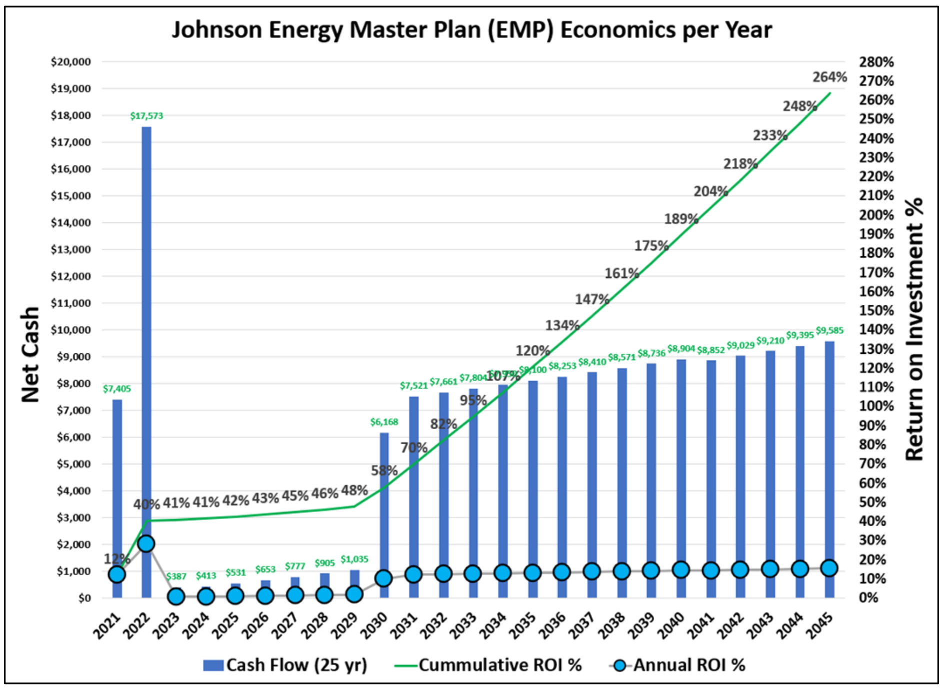
Maryland Case Study

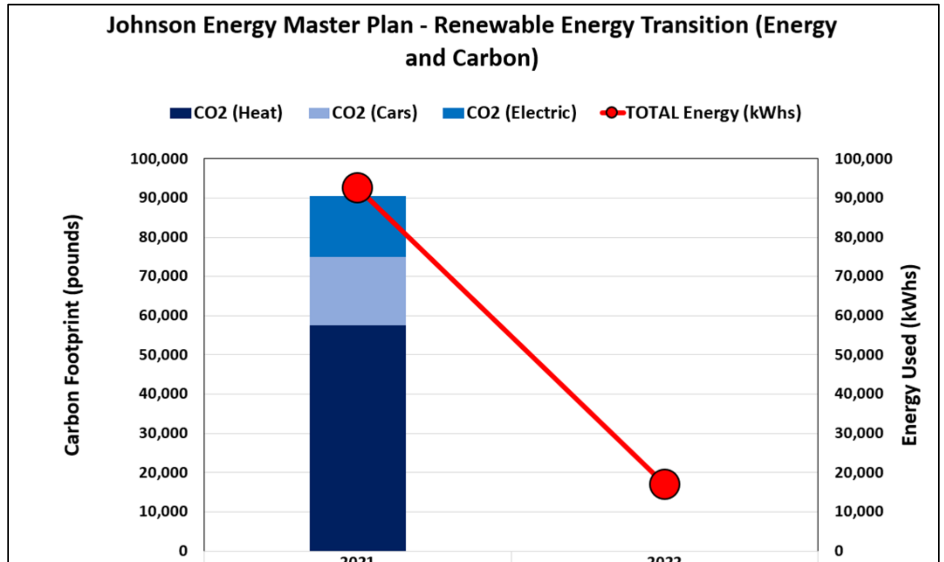
Includes electric, heating/cooling, and transportation energy demands.

Payback by year 7. Positive cash flow from year 1.

1 Zero (0) energy carbon footprint within 1 years

2 >75% energy consumption reduction





	2021	2022
CO2 (Electric)	15,500	0
CO2 (Cars)	17,458	0
CO2 (Heat)	57,600	0
TOTAL Energy (kWhs)	92,696	17,000

Commercial Case Study

Case study:
Parsippany Sewer Plant

Renewable Energy Investment Model

- ~10% ROI
- Payback about 10 years
- Net +$12.3 M over 20 years

Assumptions

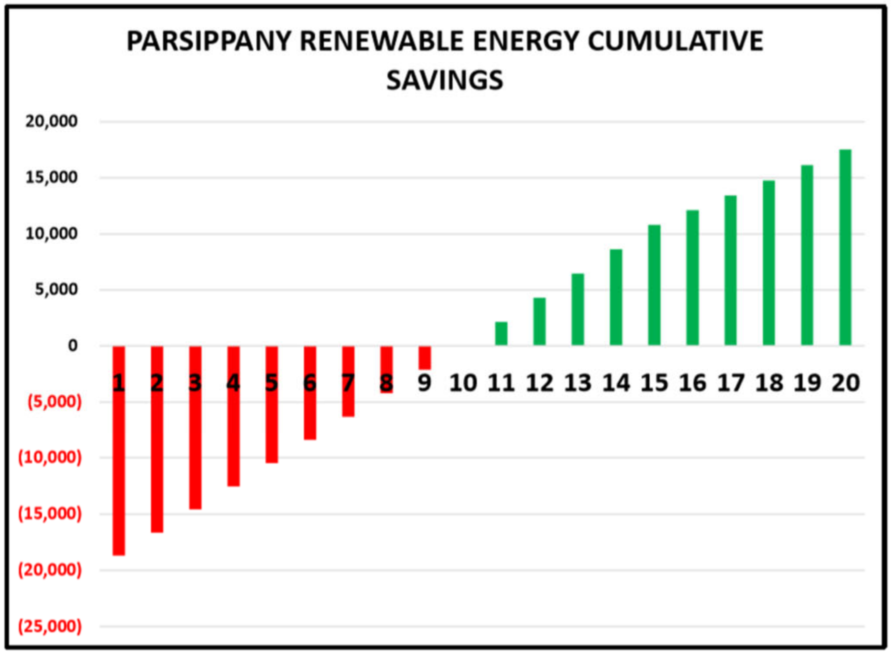
- Assumes 1% solar degradation / yr
- NJ TREC = $125/MWh for 15 years
- 2% electric and natural gas escalator / yr
- $25k / 1000 therms GSHP
- $3.10/W for solar (average/estimated)
- 10% electric reduction factor for GSHP

Assumptions

Degredation / yr		1.0%
TREC $/MWh	$	125
Escalator		2%

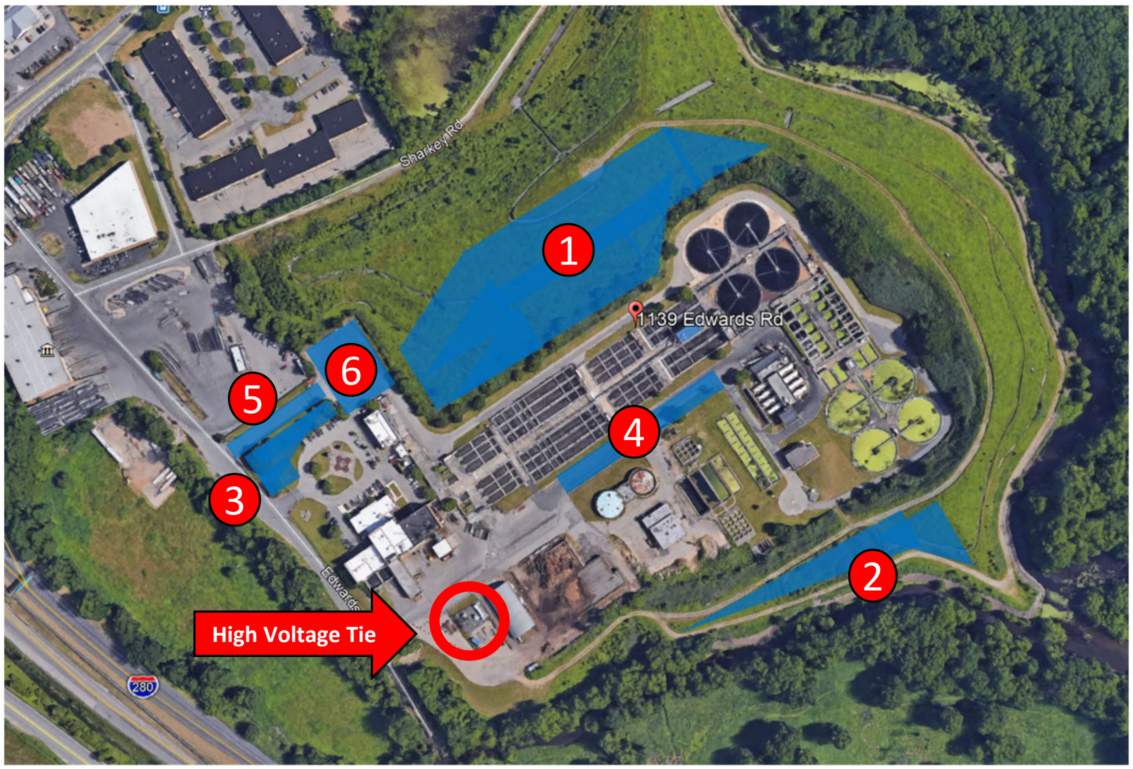
RENEWABLE ENERGY ECONOMIC MODEL

YEAR	ELECTRIC COSTS	GAS COSTS	TOTAL COSTS (Avoided)	*After ITC* SOLAR + GSHP COSTS	SOLAR OUTPUT MWh / yr	NJ TREC BENEFIT	TOTAL SAVINGS	CUMULATIVE SAVINGS
1	863	94	957	(20,704)	8,562	1,070	2,027	(18,677)
2	880	96	976		8,477	1,060	2,036	(16,641)
3	898	98	996		8,392	1,049	2,045	(14,596)
4	916	100	1,016		8,308	1,039	2,054	(12,542)
5	934	102	1,036		8,225	1,028	2,064	(10,478)
6	953	104	1,057		8,143	1,018	2,074	(8,404)
7	972	106	1,078		8,061	1,008	2,085	(6,319)
8	991	108	1,099		7,981	998	2,097	(4,222)
9	1,011	110	1,121		7,901	988	2,109	(2,113)
10	1,032	112	1,144		7,822	978	2,121	9
11	1,052	114	1,167		7,744	968	2,135	2,143
12	1,073	117	1,190		7,666	958	2,148	4,291
13	1,095	119	1,214		7,590	949	2,162	6,454
14	1,117	121	1,238		7,514	939	2,177	8,631
15	1,139	124	1,263		7,439	930	2,193	10,823
16	1,162	126	1,288		7,364		1,288	12,111
17	1,185	129	1,314		7,291		1,314	13,425
18	1,209	131	1,340		7,218		1,340	14,765
19	1,233	134	1,367		7,145		1,367	16,132
20	1,257	137	1,394		7,074		1,394	17,526
TOTALS	20,972	2,281	23,252		155,916	14,978	38,230	12,319



Sewer Plant – Path to Zero Carbon - Solar & Geothermal

- 5.7 Million kWh consumption per year
- 4.9 Megawatt (MW) solar combination of ground and carport
- 20 GSHP wells to offset 19,400 therms of Natural Gas



Solar

Zero Carbon in 2020!

- 26% ITC
- TRECs w NJ (15 yrs)
- Electric Savings

	Sewer Plant	Location	kW	Annual kWh Production	Cost ($Ks) (estimated)
1	GFT # 1	North hill - south face	3,150	3,780,000	$ 9,450
2	GFT # 2	South hill - south face	675	776,250	$ 2,025
3	GFT # 3	Front lawn	225	247,500	$ 675
4	Carport # 1	Along Access road	350	402,500	$ 1,138
5	Carport # 2	Along entry road	120	138,000	$ 390
6	Carport # 3	Large parking lot	440	506,000	1,430
		TOTALS	4,960	5,850,250	$ 15,108

Ground Source Heat Pumps (GSHP)

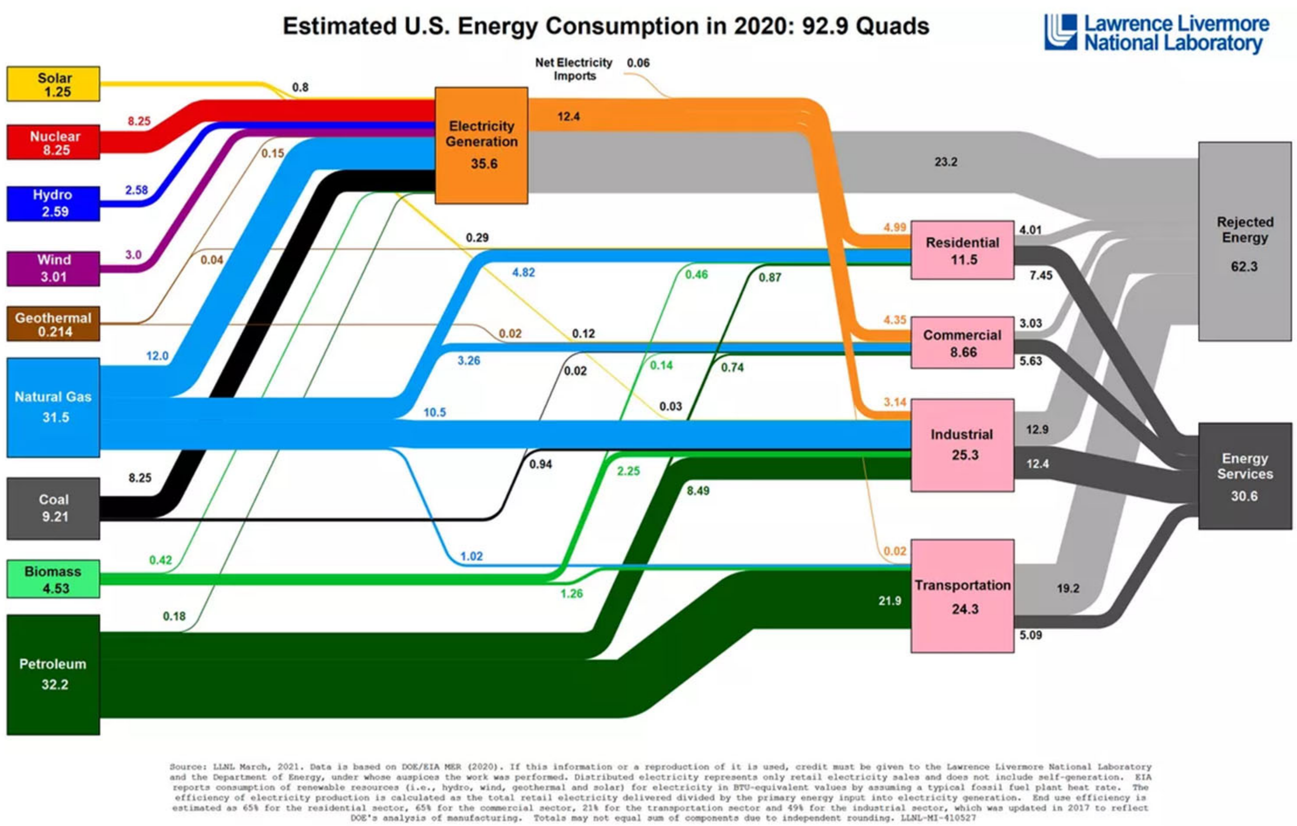
- 20 – 300’ wells
- $12.5k / 1000 Therms
- $242k cost
- 10% ITC
- Reduces cooling demand
- Eliminate dependence on natural gas
- Air source HP option (increases electric)

Battery Storage

- Back up power for resiliency (option)

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



References:

- [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)

Green Insight

<u>Ground Source Heat Pumps – Types [1]</u>

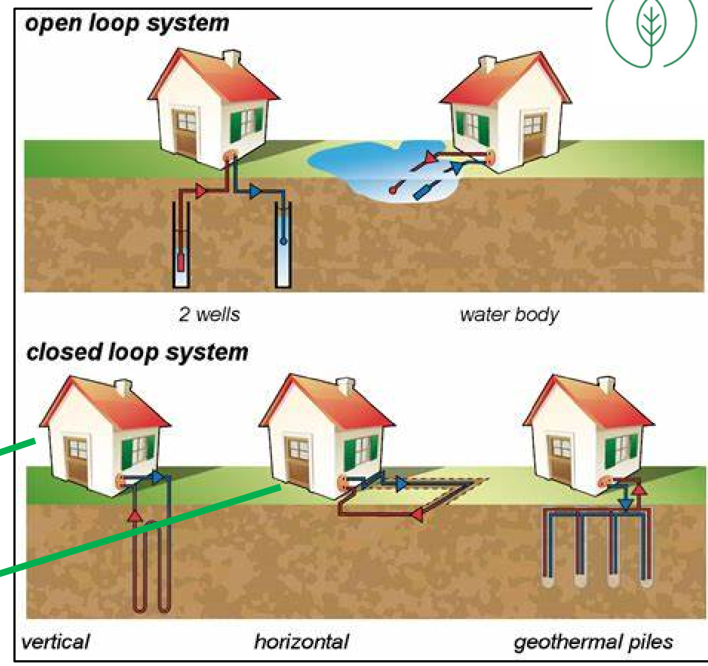
1 Open Loop

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

1



2

<u>**(B)** Vertical Drilled Borehole</u>

<u>**(C)** Horizontal Trench</u>

<u>**(D)** Submerged Pond Loop</u>

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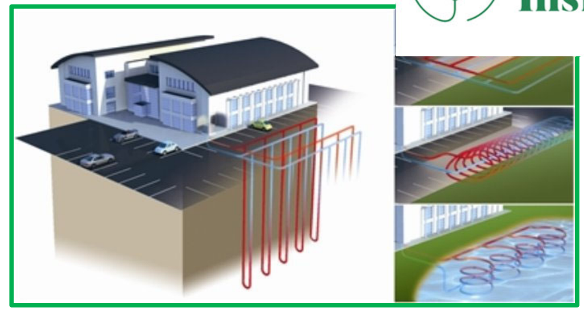
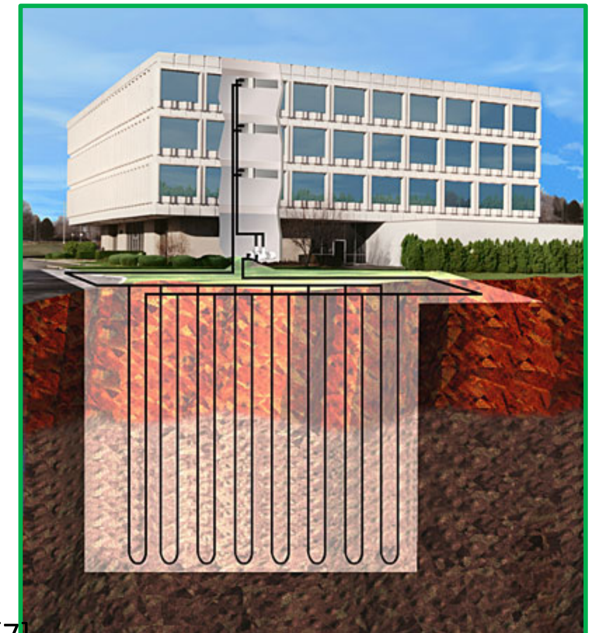
Ground Source Heat Pump – Commercial

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





[7]

Green Insight

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