Stan Crisp, PE
Application Engineer
AquaCal, Inc.
stanc@aquacal.com
Cell Number: 910.880.2312

ENERGY EFFICIENCY
Down on Your Farm

OBJECTIVES

To Help You Better Understand

Your Energy Situation

& Your Options

Outline

Pumping

Variable Speed Pumps……. Air Lift Pumps

Lighting

Incandescent….Fluorescent….LED's…Others (Halogen, Metal Halide, Low& Hi Pressure Sodium)

Heating /Chilling

Electric Resistance….*Propane….Natural Gas….Heat Pumps*

Solar

Photo Voltaic….Wind….Hydroelectric

Grants

USDA ….REAP….DSIRE

Conservation

Insulation and "R" Values….Fiberglass….Spray Foam….Heat Recovery Ventilators

Heat Load Calculations

Aquaculture-Greenhouse-Aquaponics-Hydroponics

Pumping Water

Variable Speed Pumps

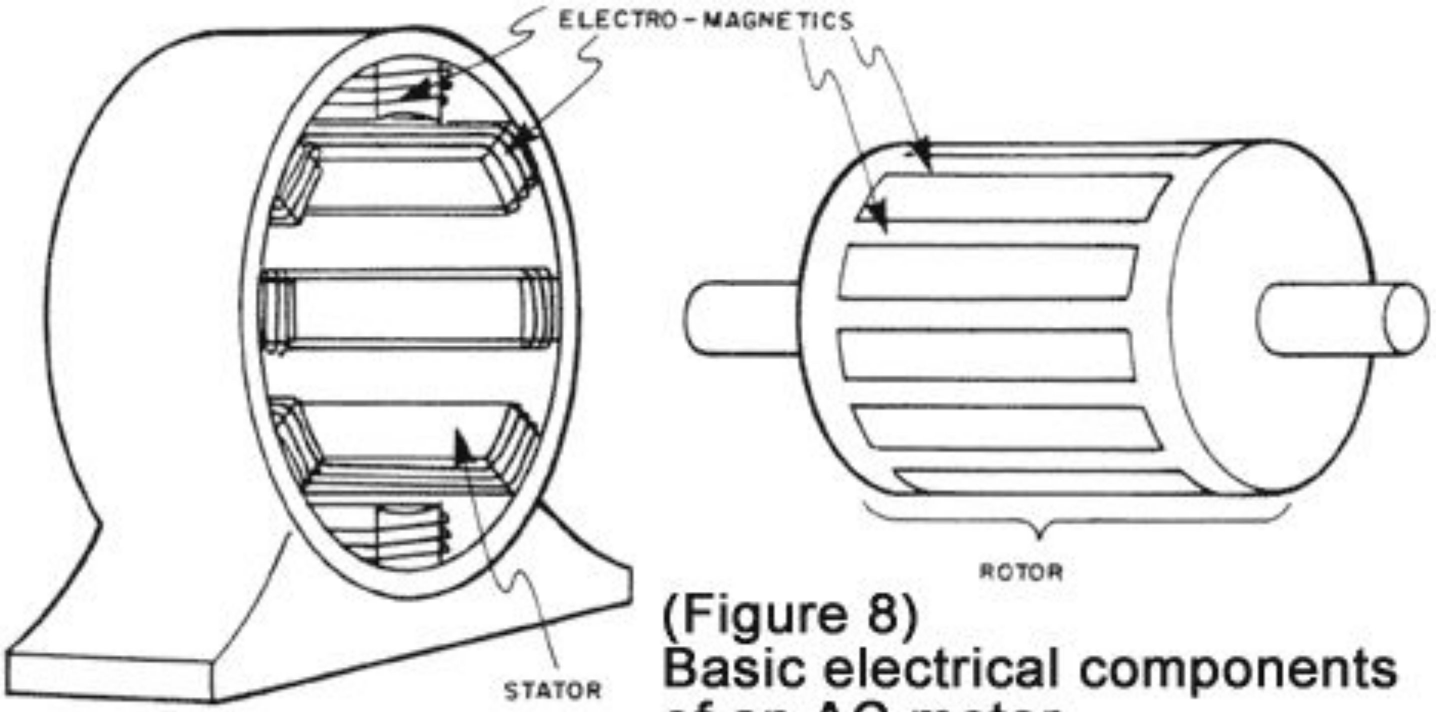
Pumping Energy =

Volume Flow x Pressure Change x Density

How They Work

* AC Motor Synchronous Speed is:
* Frequency / Pairs of Motor Poles=RPM
* Example : [60 HZ.*60 sec/minute]/1 Pair of Motor Poles= **3600** RPM
* Example: [60 HZ.*60 sec/minute]/2 Pair of Motor Poles=**1800** RPM

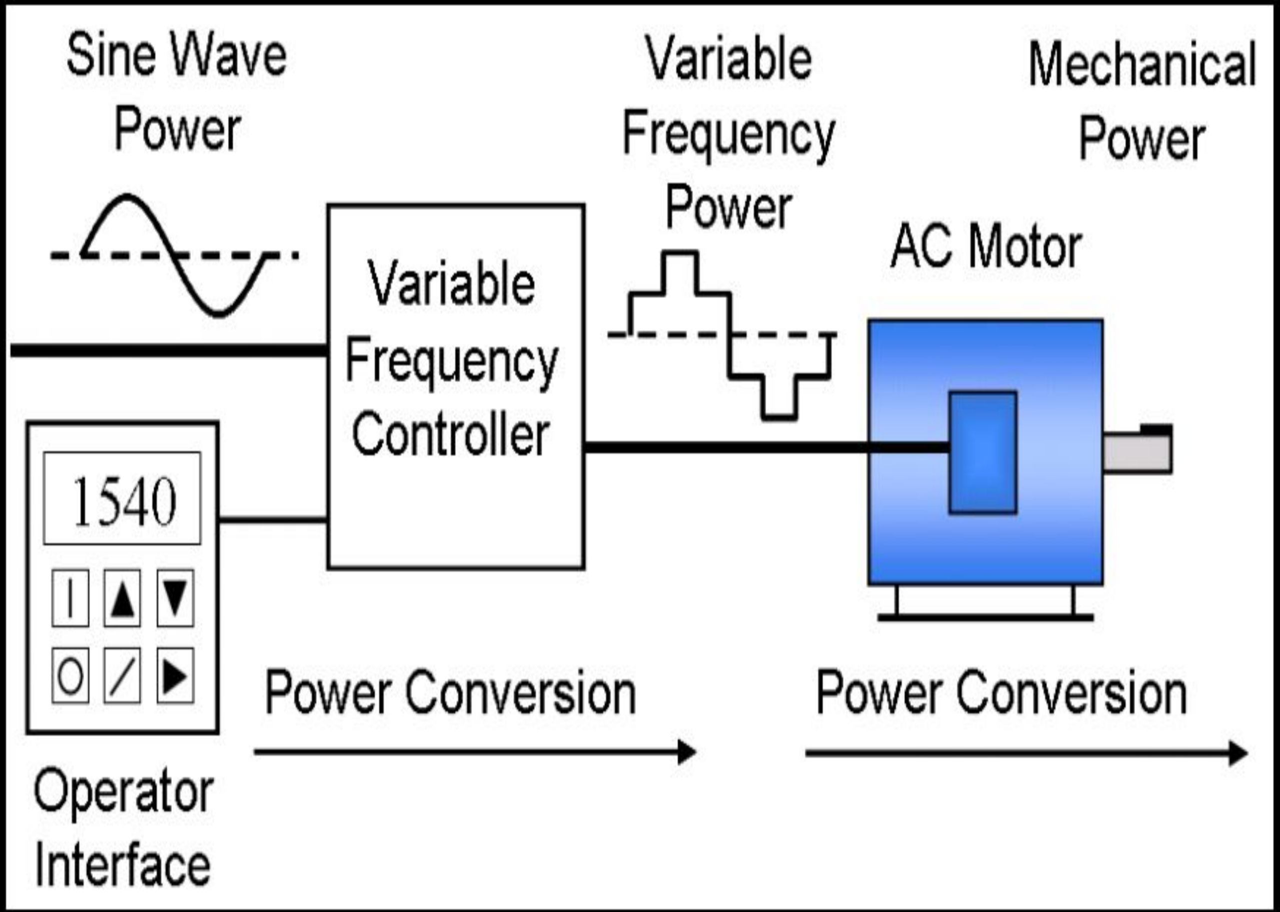
Motor Poles



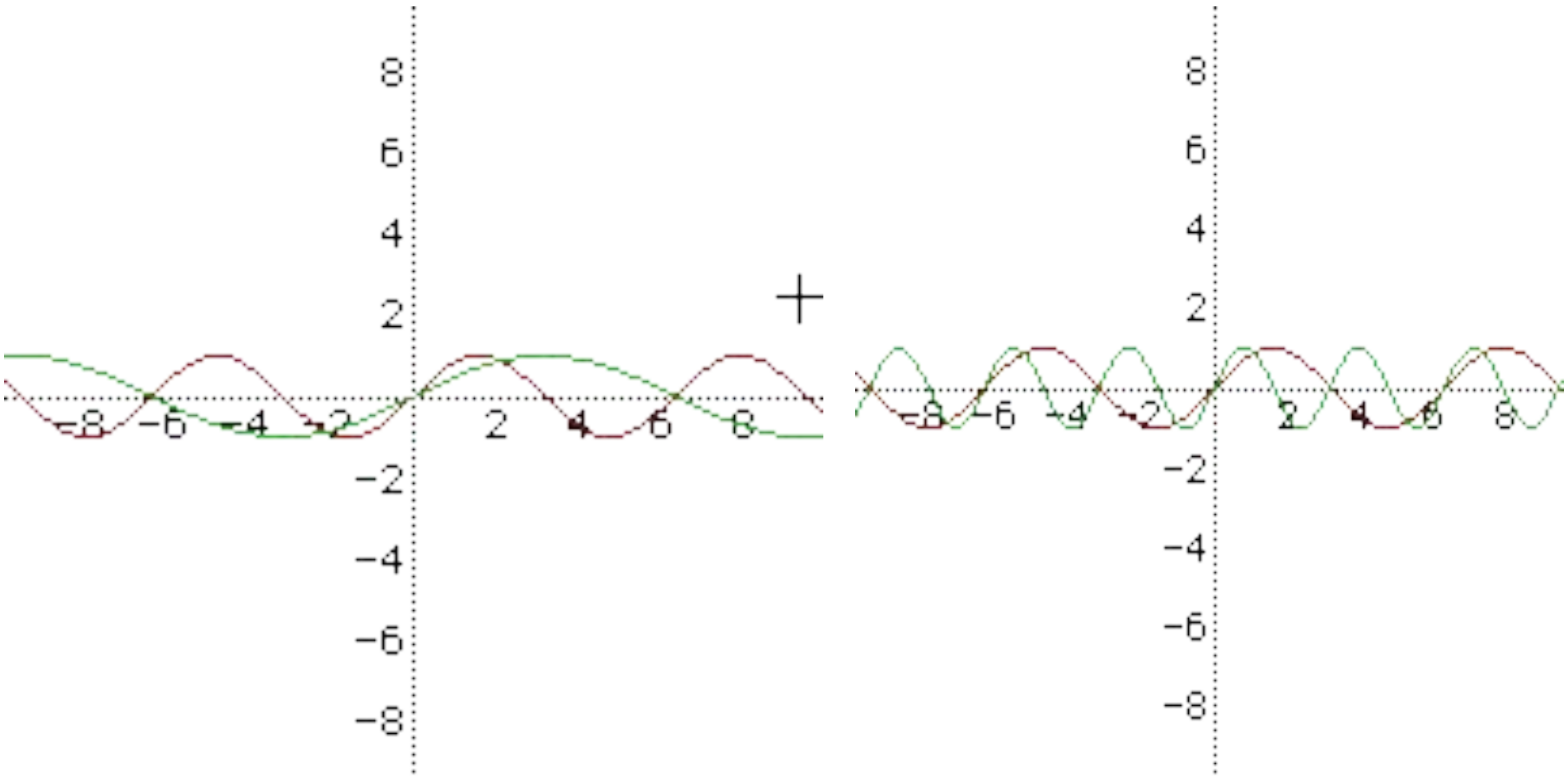
(Figure 8)
Basic electrical components of an AC motor

How They Work

* Electronically Vary the Frequency of the Supply Power
* Variable Frequency Drive (VFD)


Sine Wave Power
Variable Frequency Power
Mechanical Power
AC Motor
Variable Frequency Controller
1540
Operator Interface
Power Conversion
Power Conversion

What Variable Frequency Looks Like



Variable Speed Pumps

Pumping Energy =

Volume Flow x Pressure Change x Density

In Summary

Variable Speed Pumps Save Energy by Delivering

Only the Amount of Flow Needed

By Controlling Pump Speed

By Controlling the Frequency of the Delivered Power

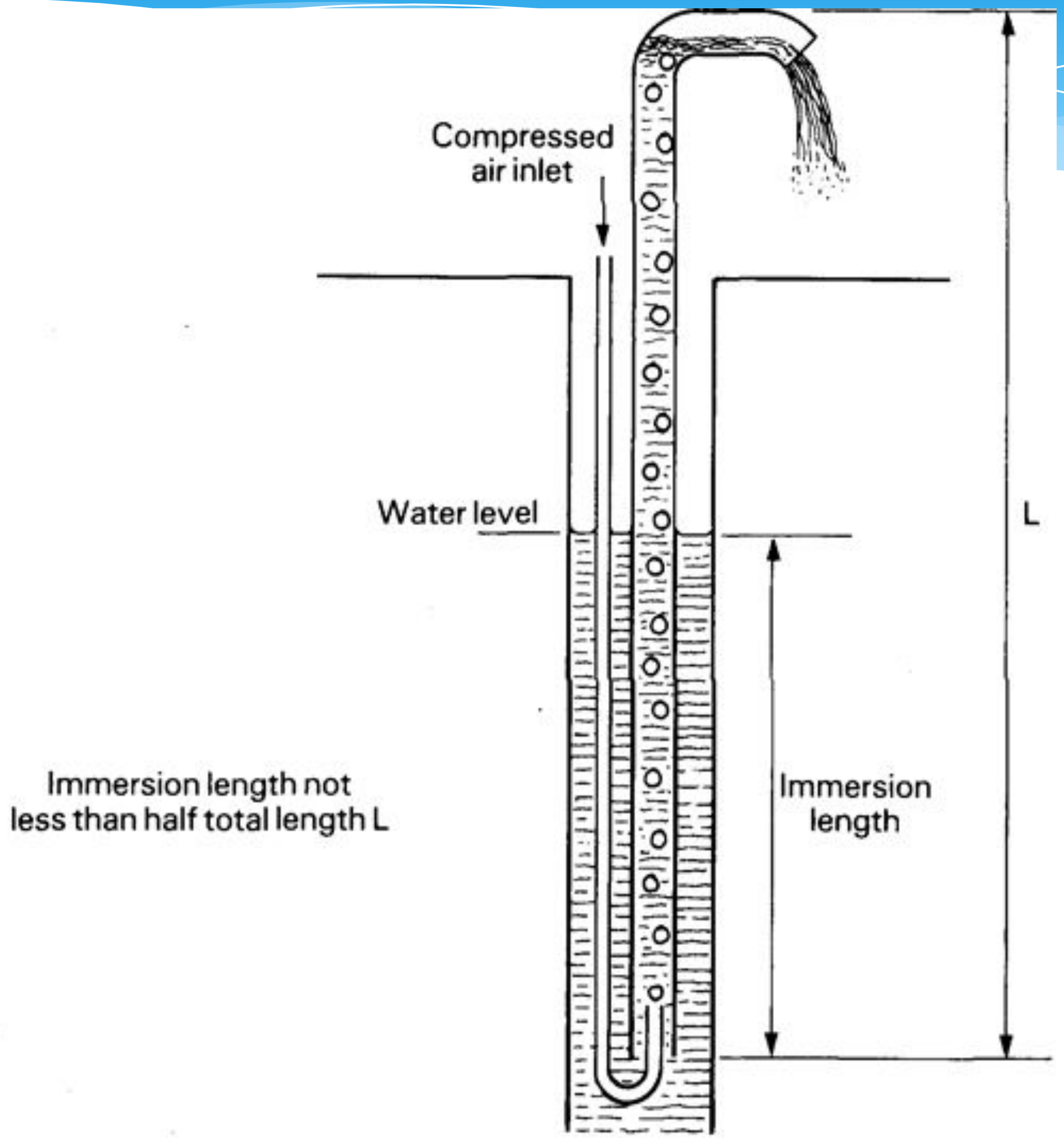
Air Lift Pumps

Volume Flow x Pressure Change x Density

Raising the Level of Water

By

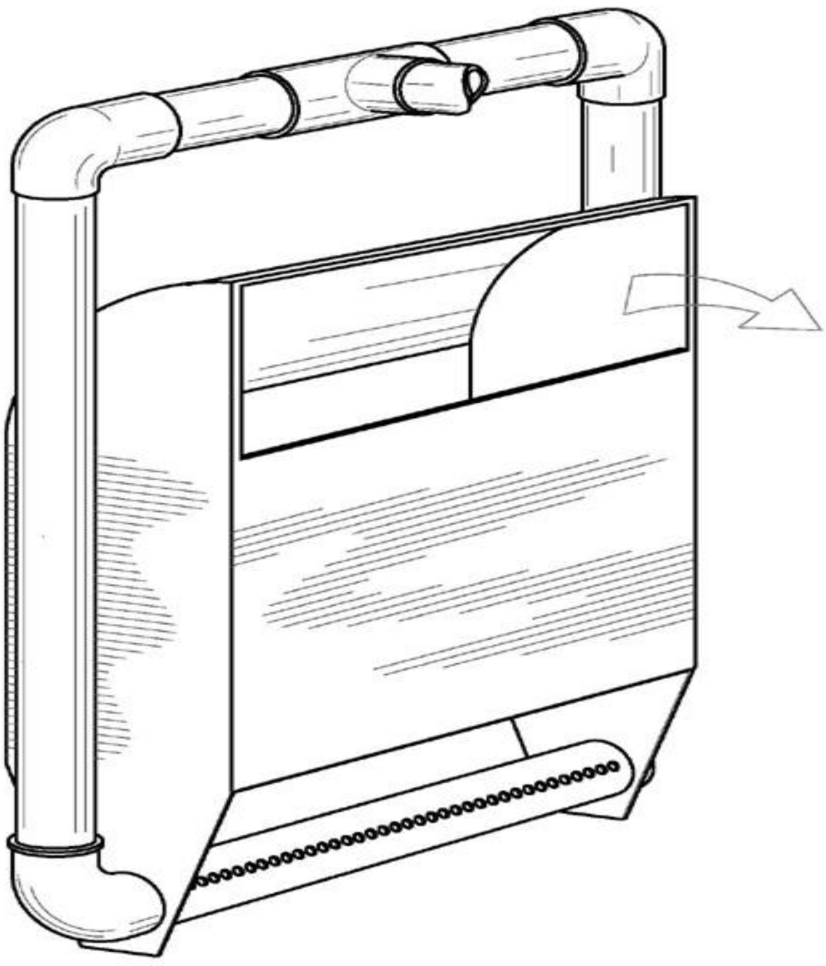
Decreasing It's Density


Compressed air inlet
Water level
L
Immersion length
Immersion length not less than half total length L

Concept Air Lift Pumps

* https://www.youtube.com/watch?v=fpfjOs0IZfk

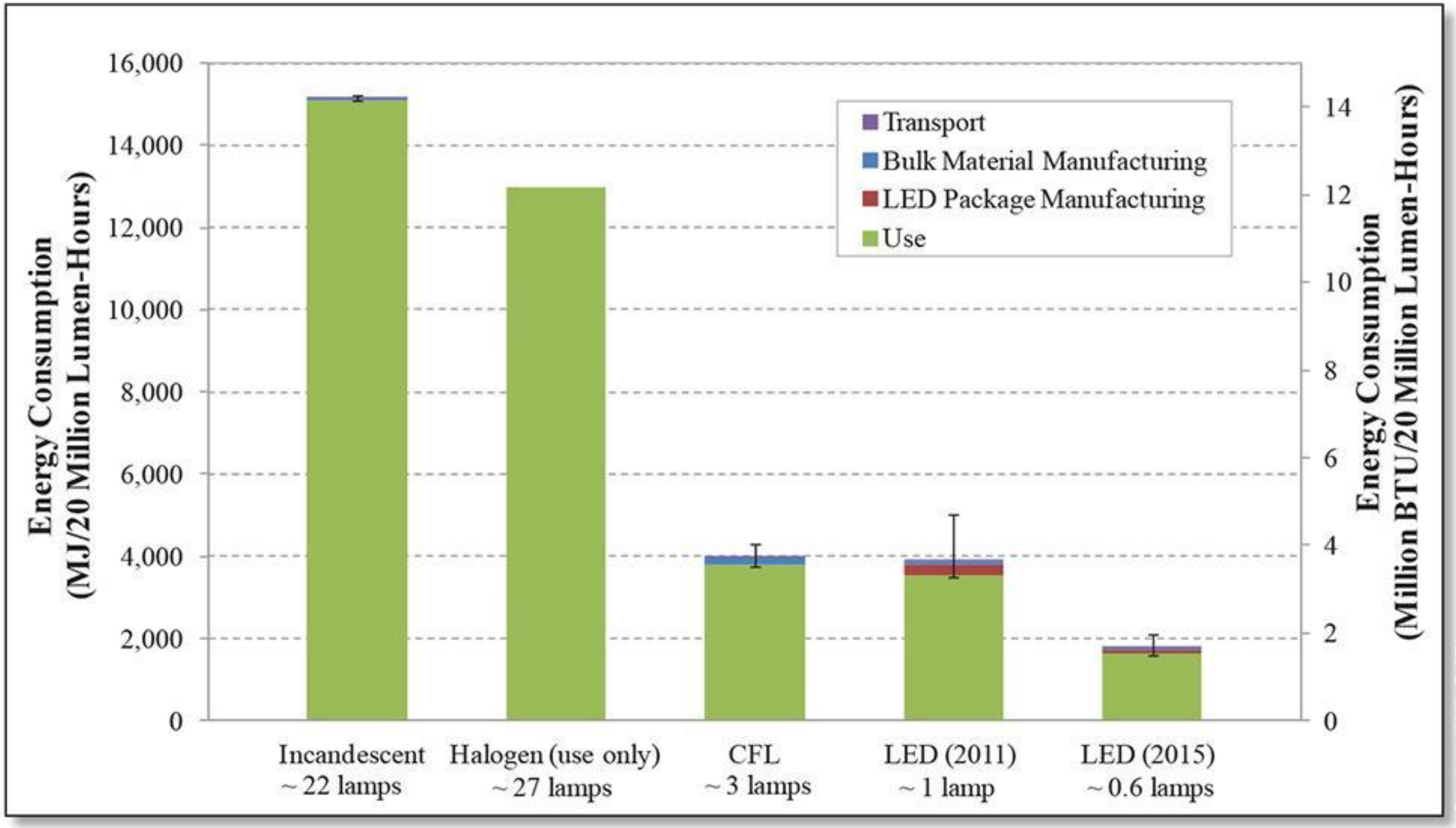
Pond Circulator



Lighting

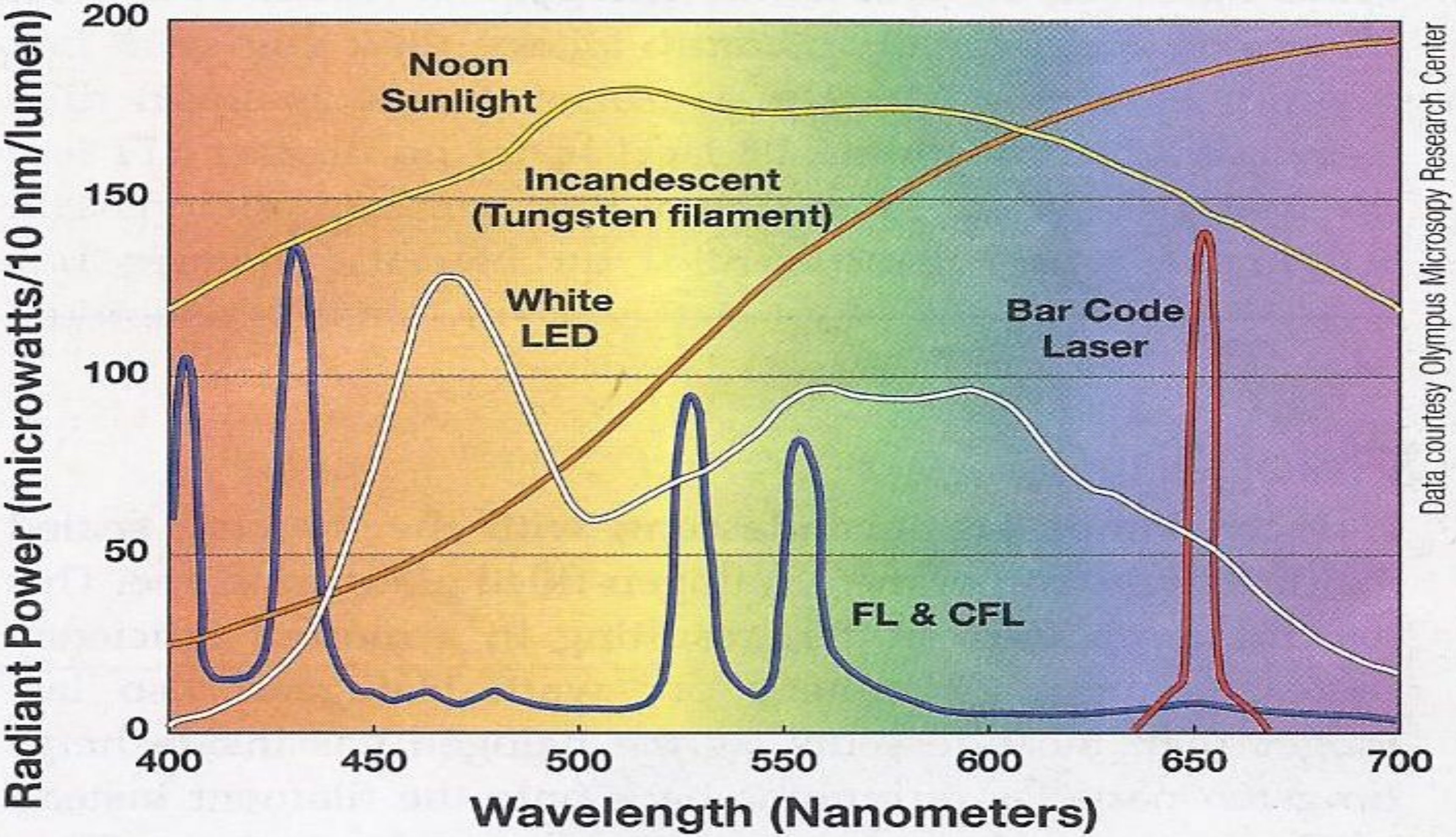
TYPE	Operating Cost	Life
Incandescent	100%	1
Fluorescent	25-35%	x10
Halogen	80%	1
Metal Halide (MH)	20%	x20
Lo & Hi Pressure Sodium	20%	x30
Light Emitting Diode (LED)	12-15%	x25

Life-Cycle Energy of Incandescent, CF & LED Lamps

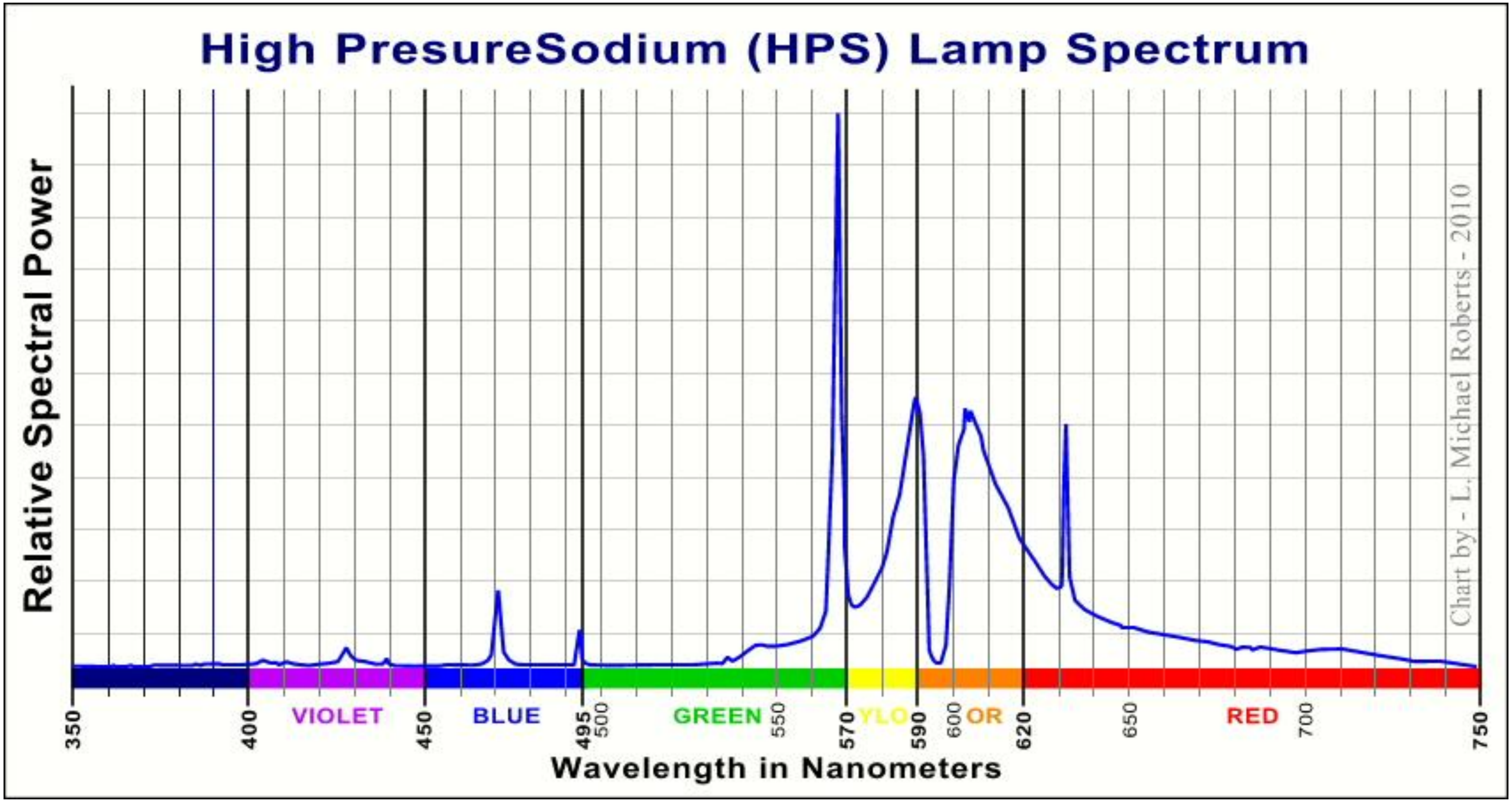


Courtesy U.S. DOE

Spectral Distribution of Common Light Sources



High Pressure Sodium



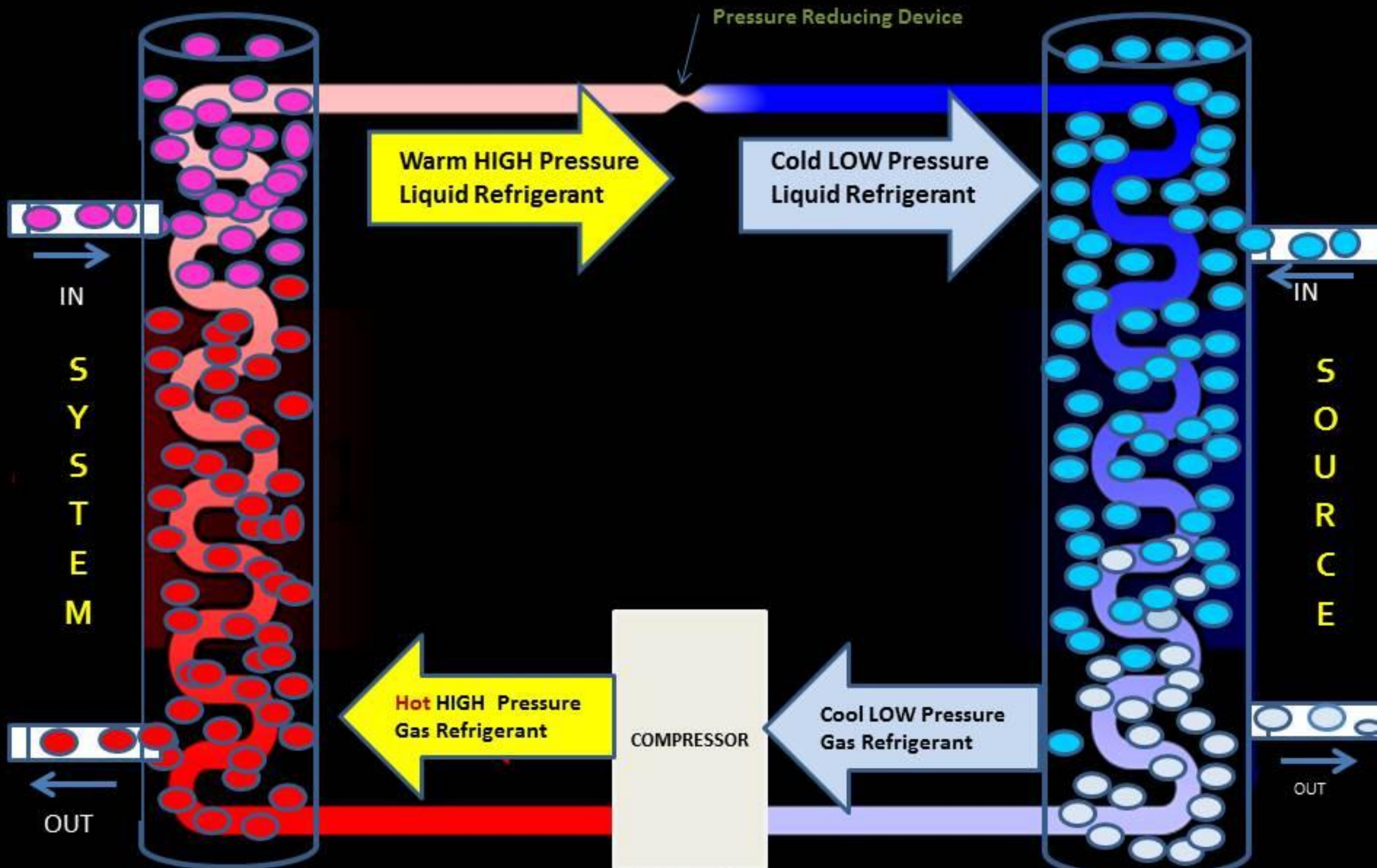
Heating & Chilling

Heating Comparison: An Example

* Required for 4,600 ft.² double poly insulated greenhouse
  * 10°F over outside temp, measuring BTU's

Fuel Type	Amount Used/Day	Price/ Unit	Total Price
Electric Resistance Heating (KW)	304.13	$0.08	$24.33
Gallons Fuel Oil	7.68	$3.04	$23.37
Gallons of Propane	11.31	$1.80	$20.37
Therm of Natural Gas	10.37	$1.02	$10.59
Air Source Heat Pump (COP=3.5)	86.87	$0.08	$ 6.95
Geothermal Heat Pump (COP=5.0)	60.81	$0.08	$ 4.87
Pounds of Wood Chips	230.61	$0.01	$ 2.88

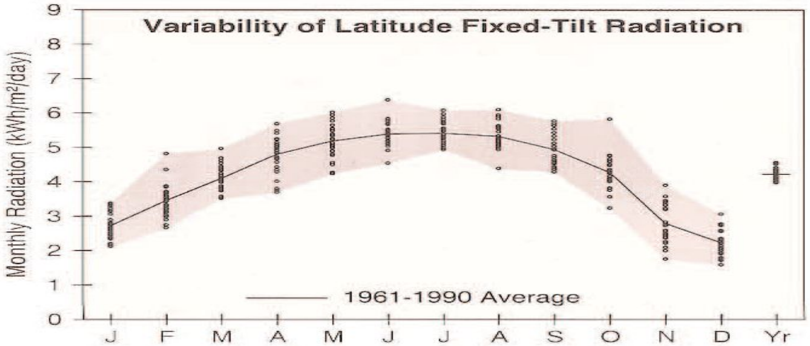
Geothermal Heat Pump: How it Works



How a Heat Pump Works

https://www.youtube.com/watch?v=S0Jy56MZW4w

Solar



Columbus, OH

WBAN NO. 14821

LATITUDE: 40.00° N
LONGITUDE: 82.88° W
ELEVATION: 254 meters
MEAN PRESSURE: 988 millibars

STATION TYPE: Secondary

Solar Radiation for Flat-Plate Collectors Facing South at a Fixed Tilt (kWh/m²/day), Uncertainty ±9%

Tilt (°)		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
0	Average	1.8	2.5	3.5	4.6	5.5	6.0	5.9	5.3	4.3	3.1	1.9	1.5	3.8
	Min/Max	1.5/2.1	2.2/3.2	3.1/4.0	3.7/5.3	4.6/6.4	5.1/7.1	5.4/6.5	4.5/5.9	3.8/4.8	2.6/4.0	1.4/2.3	1.2/1.7	3.6/4.1
Latitude -15	Average	2.5	3.2	4.0	4.9	5.5	5.9	5.8	5.5	4.9	4.0	2.6	2.0	4.2
	Min/Max	2.0/3.0	2.6/4.4	3.5/4.8	3.8/5.8	4.5/6.4	4.9/6.9	5.3/6.5	4.6/6.3	4.3/5.7	3.1/5.4	1.7/3.5	1.5/2.7	4.0/4.6
Latitude	Average	2.7	3.4	4.1	4.8	5.2	5.4	5.4	5.3	4.9	4.3	2.8	2.2	4.2
	Min/Max	2.1/3.4	2.7/4.8	3.5/5.0	3.7/5.7	4.2/6.0	4.6/6.4	4.9/6.1	4.4/6.1	4.3/5.8	3.2/5.8	1.8/3.9	1.6/3.1	4.0/4.6
Latitude +15	Average	2.9	3.5	4.0	4.4	4.6	4.7	4.8	4.8	4.7	4.3	2.9	2.3	4.0
	Min/Max	2.2/3.6	2.7/5.1	3.4/4.9	3.4/5.3	3.8/5.3	4.0/5.5	4.3/5.3	4.0/5.6	4.1/5.5	3.2/5.9	1.8/4.1	1.6/3.3	3.7/4.3
90	Average	2.6	3.0	3.0	2.8	2.6	2.4	2.5	2.9	3.3	3.4	2.5	2.1	2.8
	Min/Max	1.9/3.5	2.2/4.7	2.5/3.7	2.2/3.3	2.2/2.9	2.2/2.7	2.4/2.8	2.4/3.3	2.9/3.9	2.5/4.8	1.4/3.7	1.4/3.1	2.6/3.0

Solar Radiation for 1-Axis Tracking Flat-Plate Collectors with a North-South Axis (kWh/m²/day), Uncertainty ±9%

Axis Tilt (°)		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
0	Average	2.3	3.3	4.4	5.8	6.9	7.6	7.5	6.8	5.7	4.3	2.4	1.8	4.9
	Min/Max	1.9/2.9	2.5/4.5	3.7/5.4	4.3/7.2	5.4/8.6	6.3/9.3	6.6/8.6	5.5/8.1	4.8/6.7	3.1/5.8	1.5/3.3	1.4/2.5	4.6/5.4
Latitude -15	Average	2.8	3.8	4.8	6.1	7.0	7.5	7.5	7.1	6.2	4.9	2.9	2.3	5.3
	Min/Max	2.2/3.6	2.8/5.4	4.0/6.0	4.4/7.7	5.4/8.7	6.2/9.3	6.6/8.7	5.6/8.4	5.2/7.4	3.5/6.9	1.8/4.2	1.6/3.2	4.9/5.8
Latitude	Average	3.1	4.0	4.9	6.0	6.8	7.2	7.2	6.9	6.2	5.1	3.1	2.5	5.3
	Min/Max	2.3/3.9	2.9/5.8	4.1/6.2	4.3/7.6	5.2/8.4	5.9/8.9	6.4/8.4	5.4/8.3	5.2/7.5	3.7/7.3	1.8/4.5	1.7/3.5	4.9/5.8
Latitude +15	Average	3.2	4.0	4.8	5.8	6.4	6.7	6.8	6.6	6.0	5.1	3.2	2.5	5.1
	Min/Max	2.4/4.1	2.9/5.9	4.0/6.1	4.1/7.3	4.9/7.9	5.6/8.3	5.9/7.9	5.2/7.9	5.1/7.3	3.6/7.3	1.8/4.7	1.7/3.7	4.7/5.6

Solar Radiation for 2-Axis Tracking Flat-Plate Collectors (kWh/m²/day), Uncertainty ±9%

Tracker		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
2-Axis	Average	3.2	4.1	4.9	6.1	7.1	7.7	7.6	7.1	6.2	5.2	3.2	2.6	5.4
	Min/Max	2.4/4.1	2.9/5.9	4.1/6.2	4.5/7.7	5.5/8.8	6.4/9.5	6.7/8.9	5.6/8.5	5.2/7.5	3.7/7.3	1.9/4.7	1.7/3.7	5.1/6.0

Direct Beam Solar Radiation for Concentrating Collectors (kWh/m²/day), Uncertainty ±8%

Tracker		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
1-Axis, E-W	Average	1.5	1.8	2.0	2.5	3.0	3.3	3.2	3.0	2.8	2.7	1.6	1.2	2.4
Horiz Axis	Min/Max	0.7/2.4	1.0/3.0	1.3/3.1	1.3/3.6	1.8/4.3	2.3/4.8	2.5/4.2	1.9/4.0	2.0/3.7	1.5/4.4	0.7/2.9	0.6/2.2	2.1/2.9
1-Axis, N-S	Average	1.1	1.6	2.3	3.2	3.9	4.4	4.3	4.0	3.4	2.6	1.2	0.8	2.7
Horiz Axis	Min/Max	0.5/1.7	0.9/2.7	1.5/3.4	1.6/4.8	2.4/5.8	3.1/6.2	3.3/5.6	2.6/5.3	2.5/4.5	1.5/4.3	0.5/2.2	0.4/1.4	2.4/3.3
1-Axis, N-S	Average	1.7	2.2	2.7	3.4	3.8	4.1	4.1	4.1	3.8	3.3	1.8	1.3	3.0
Tilt=Latitude	Min/Max	0.7/2.6	1.2/3.6	1.7/4.1	1.7/5.1	2.4/5.6	2.9/5.9	3.1/5.3	2.6/5.4	2.8/5.1	1.9/5.5	0.7/3.2	0.6/2.3	2.6/3.6
2-Axis	Average	1.8	2.2	2.7	3.5	4.1	4.5	4.4	4.2	3.8	3.4	1.9	1.4	3.2
	Min/Max	0.8/2.8	1.2/3.7	1.7/4.1	1.7/5.1	2.5/6.0	3.1/6.4	3.3/5.7	2.7/5.6	2.8/5.1	1.9/5.5	0.8/3.4	0.7/2.5	2.8/3.8

Average Climatic Conditions

Element	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
Temperature (°C)	-3.1	-1.3	4.9	10.6	16.2	20.7	22.9	21.9	18.6	12.1	6.1	-0.1	10.8
Daily Minimum Temp	-7.5	-6.0	-0.4	4.4	10.1	14.4	17.1	16.0	12.7	6.1	1.3	-4.1	5.3
Daily Maximum Temp	1.2	3.3	10.3	16.7	22.4	26.9	28.7	27.8	24.6	18.1	10.8	4.0	16.2
Record Minimum Temp	-28.3	-25.0	-21.1	-10.0	-3.9	1.7	6.1	3.9	-0.6	-6.7	-15.0	-27.2	-28.3
Record Maximum Temp	23.3	22.8	29.4	31.7	34.4	38.9	37.8	38.3	37.8	32.2	26.7	24.4	38.9
HDD, Base 18.3°C	665	551	415	233	104	13	0	7	45	201	368	570	3171
CDD, Base 18.3°C	0	0	0	0	38	83	143	119	53	6	0	0	443
Relative Humidity (%)	71	69	65	63	67	68	71	73	73	69	72	74	70
Wind Speed (m/s)	4.4	4.2	4.6	4.3	3.7	3.3	3.0	2.8	2.9	3.3	4.0	4.3	3.7

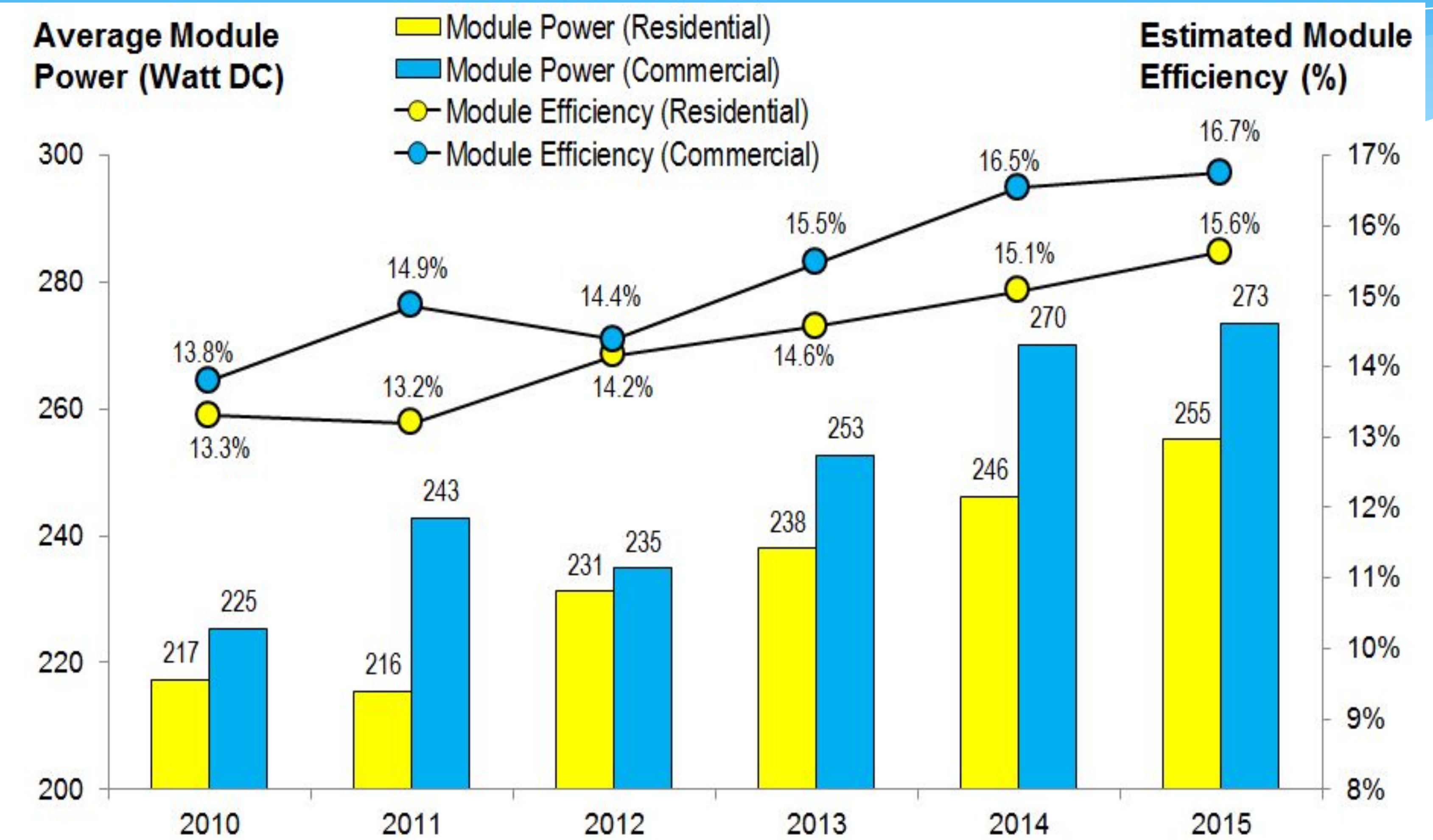
Solar Radiation Data Manual
for
Flat-Plate and Concentrating Collectors

http://rredc.nrel.gov/solar/pubs/redbook/

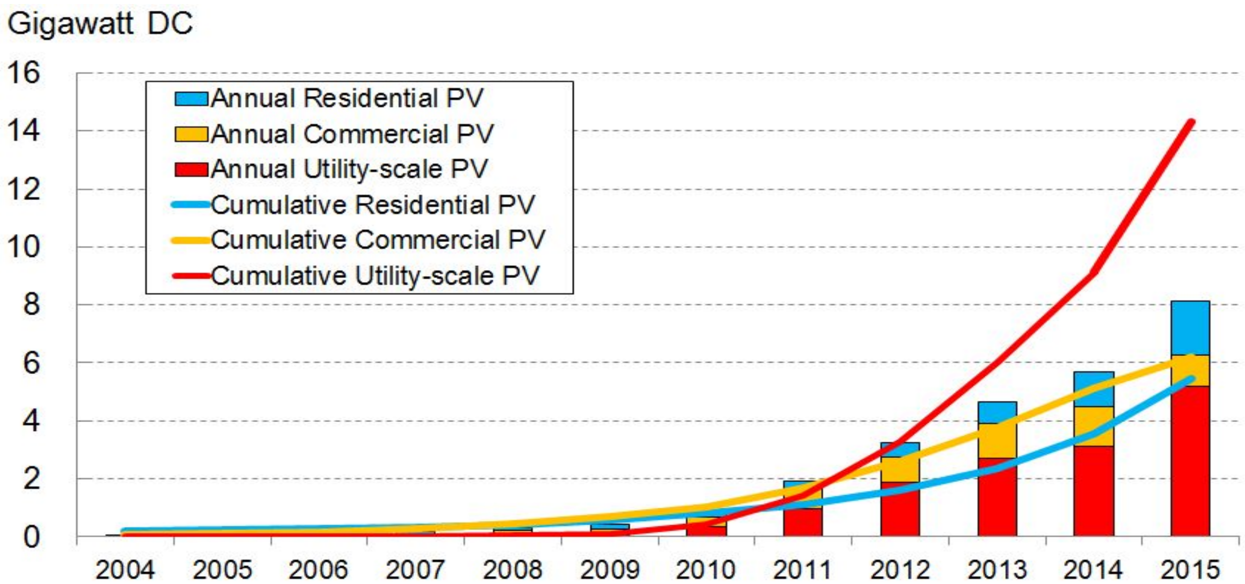
Thanks To:
National Renewable Energy Laboratory (NREL)

* **U.S. Solar Photovoltaic System Cost Benchmark: Q1 2016 by**
* Ran Fu, Donald Chung, Travis Lowder, David Feldman, Kristen Ardani, and Robert Margolis

Module power and efficiency trends from the California NEM database (Go Solar CA 2016), 2010–2015

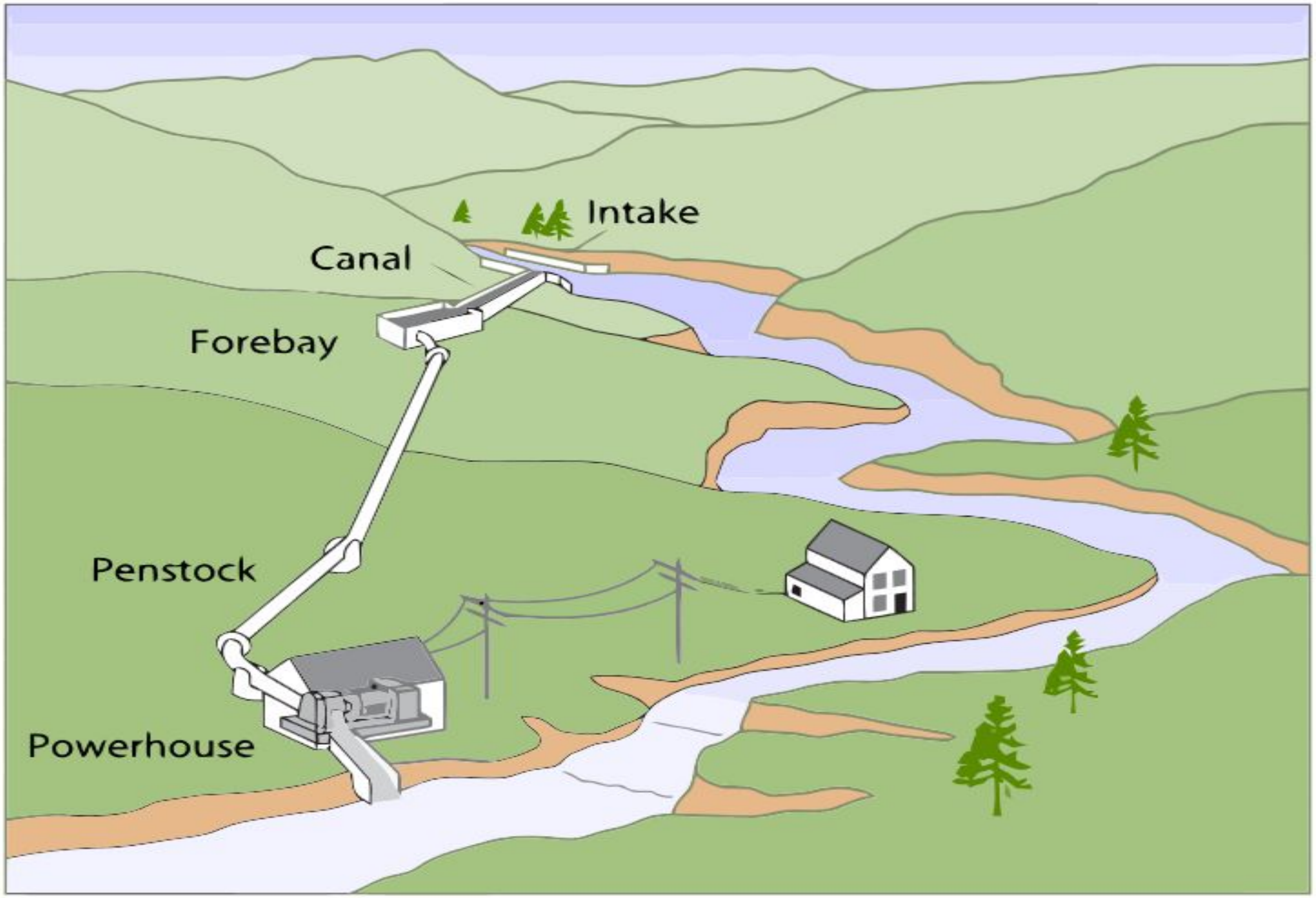


U.S. PV market growth, 2004–2015, in gigawatts of direct current (DC) capacity (Bloomberg 2016)



Hydroelectric

Hydroelectric Power



In this microhydropower system, water is diverted into the pen-stock. Some generators can be placed directly into the stream.

HYDROELECTRIC POWER

Theoretical Output P=Q*H/k

Power=Flow*Head/constant

KW=GPM*Feet/5310

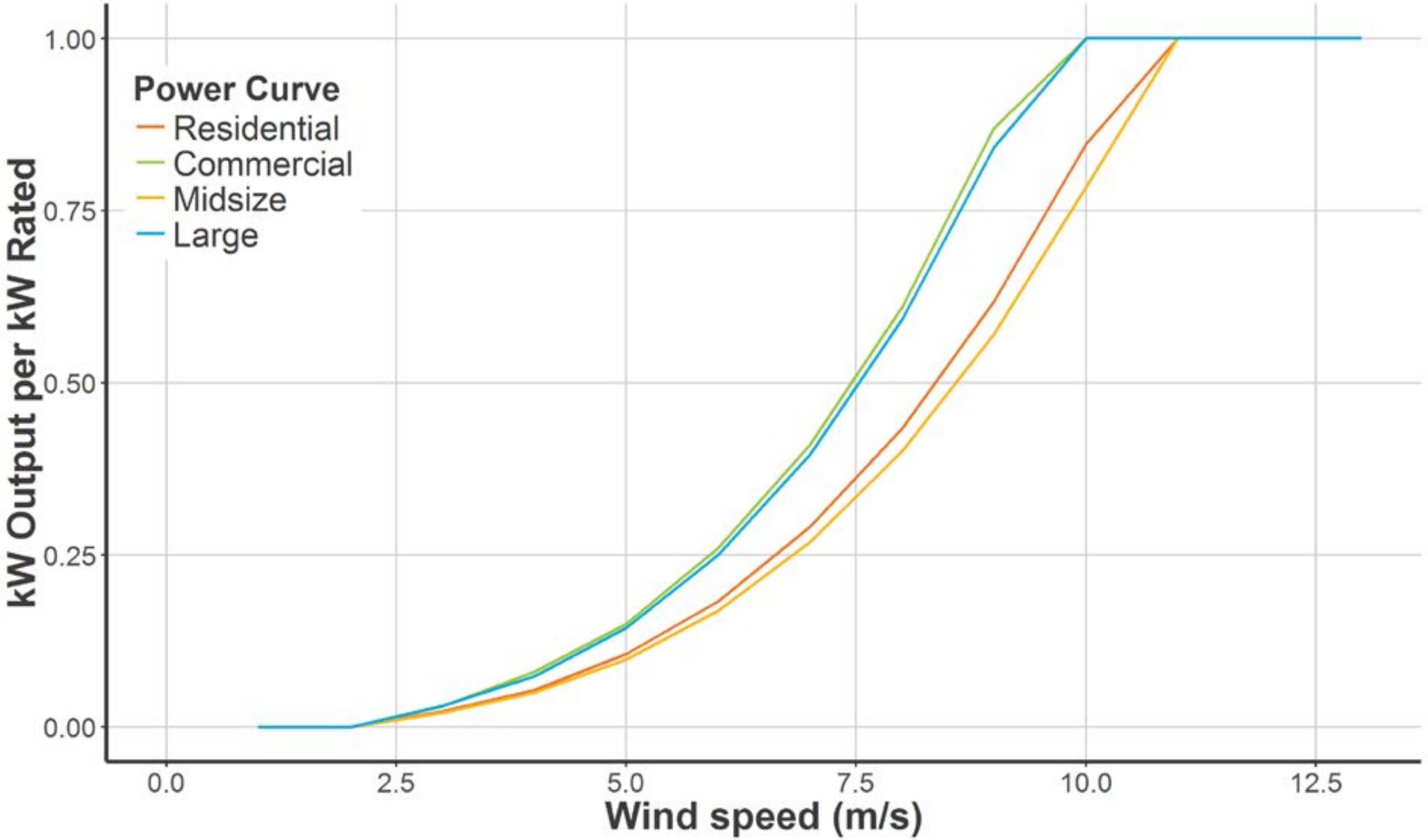
5.65KW=500GPM*60'/5310

Wind

WIND

Wind farm	Current capacity (MW)	Country	Refs
Gansu Wind Farm	6,000	China	[25][26]
Muppandal wind farm	1,500	India	[27]
Alta (Oak Creek-Mojave)	1,320	United States	[28]
Jaisalmer Wind Park	1,064	India	[29]
Shepherds Flat Wind Farm	845	United States	[30]
Roscoe Wind Farm	782	United States	
Horse Hollow Wind Energy Center	736	United States	[31][32]
Capricorn Ridge Wind Farm	662	United States	[31][32]
Fântânele-Cogealac Wind Farm	600	Romania	[33]
Fowler Ridge Wind Farm	600	United States	[34]
Whitelee Wind Farm	539	United Kingdom	[35

Wind Turbine Output



Grants

* US Dept. Agriculture   Rural Energy for America (REAP)

Grant Request
For Enterprises with at least 50% of Gross Income from Agriculture

How may the funds be used?
Funds may be used for renewable energy systems, such as:

Biomass (for example: biodiesel and ethanol, anaerobic digesters, and solid fuels)

Geothermal for electric generation or direct use

Hydropower below 30 megawatts

Hydrogen

Small and large wind generation

Small and large solar generation

Ocean (tidal, current, thermal) generation

Grants

http://www.dsireusa.org/

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Database of State Incentives for Renewables & Efficiency®

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100%

OAA | Database of State ... | OAA 2017 - Micro... | 11:44 AM

INSULATION

Insulation Facts

"R" Value is a Measure of the Resistance to Transfer Heat
K Valve is a Measure of the Ability to Transfer Heat (Conductivity)

R=1/K or K=1/R

K (Conductivity)BTU/hr. *ft2 *Deg. F

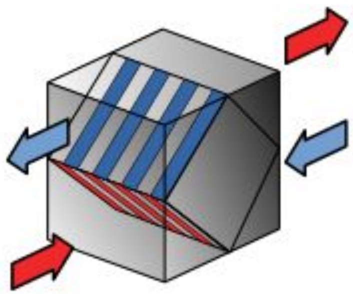
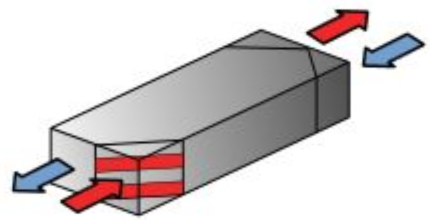
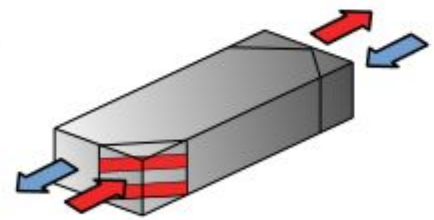
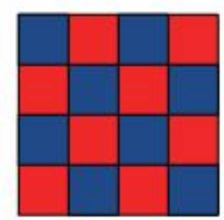
Example
for an R value of 4 K = .25

.25 BTU/hr. x 100 sq. ft. x 10 degrees =250 BTU/hour

"R" Values

3 ½" Spun Fiberglass= R-13
1" Polyurethane Foam R=6.25
1" Polystyrene Foam R=5
1" Soil R=.125 to .25
8" Concrete Block R=1.1
Inflated Double Poly R=1.4
1/8" Glass R=.9
Double Pane Insulated Glass R=2.25

Heat Recovery Ventilators

Principle			
Profile			
Counter current Heat exchanger	Vertical flat panel	Horizontal flat panel	Cellular
Efficiency	50 – 70 %	70 – 80 %	85 – 99 %

Heat Load Calculations

Aquaculture

http://www.engineeringtoolbox.com/evaporation-water-surface-d_690.html

Greenhouse

http://www.littlegreenhouse.com/heat-calc.shtml

Aquaponics

Hydroponics

AquaCal
AQUACULTURE HEAT PUMPS

Stan Crisp, PE
Application Engineer
AquaCal, Inc.
stanc@aquacal.com
Cell Number: 910.880.2312

Questions?????

Stuff of Interest

https://www.youtube.com/watch?v=fpfjOs0IZfk

http://rredc.nrel.gov/solar/pubs/redbook/

US Dept. Agriculture   Rural Energy for America (REAP)

http://www.dsireusa.org/

https://www.youtube.com/watch?v=S0Jy56MZW4w

http://www.engineeringtoolbox.com/evaporation-water-surface-d_690.html