

Calibrating Your Solar Energy Intuition



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Clean Energy Access

March 2010

Outline

- **Some Basic Principles about Energy and Power**
 - **Definitions**
 - **Terminology**
 - **Familiar Energy sources**
- **Solar Energy**
- **Energy Required for Common Productive Uses**

Basic Principles about Energy

What is energy?

A thermodynamic quantity equivalent to the capacity of a physical system to do work. Common units of energy are Joule, Btu, kWh

The term energy

can apply to heat energy, light energy, kinetic energy, chemical energy, and electrical energy

1 BTU = 1055 Joules

1 kWh = 3.61 million J = 3413 BTU

Energy Content of Common Fuels



Key	Fossil Fuel	Green Energy	Nuclear Fuel	Thermal	Electrical	Kinetic
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Generation Process	Fuel	Thermal Energy (Calorific Content) kWh/Kg	
Thermal	Brown Coal (Lignite)	2.8	
	Coking (Black) Coal	8.3	
	Oil	12.5	
	Natural Gas (North Sea) ^[1]	10.8	
	Liquefied Petroleum Gas (LPG) is a mixture of Propane and Butane	13.8	
	Propane	13.9	
	Butane	13.7	
	Kerosene (Paraffin Oil)	13.0	
	Petrol (Gasoline)	13.0	
	Diesel	12.9	
	Bio diesel	10.9	
	Ethanol	8.3	
	Methanol	6.4	
	Dry Wood	4.4	
	Green Wood	2.5	
	Agricultural Crop Residues	2.5 - 5.0	
	Municipal Waste	2.0 - 2.5	
	Uranium 235	22,800,000	
		Hydrogen ^[2]	39.4
		Candy Bar (Mars Bar)	5.55

Basic Principles about Power

What is power?

The rate of doing work, or energy per unit time. Units are btu/hr, hp, joules/sec, W, or kW



746 W = 1 horsepower (hp)

Fuel: oats



Human Power



Maximum Power = 400W

Fuel: BIG plates of food!



...a little less Human Power

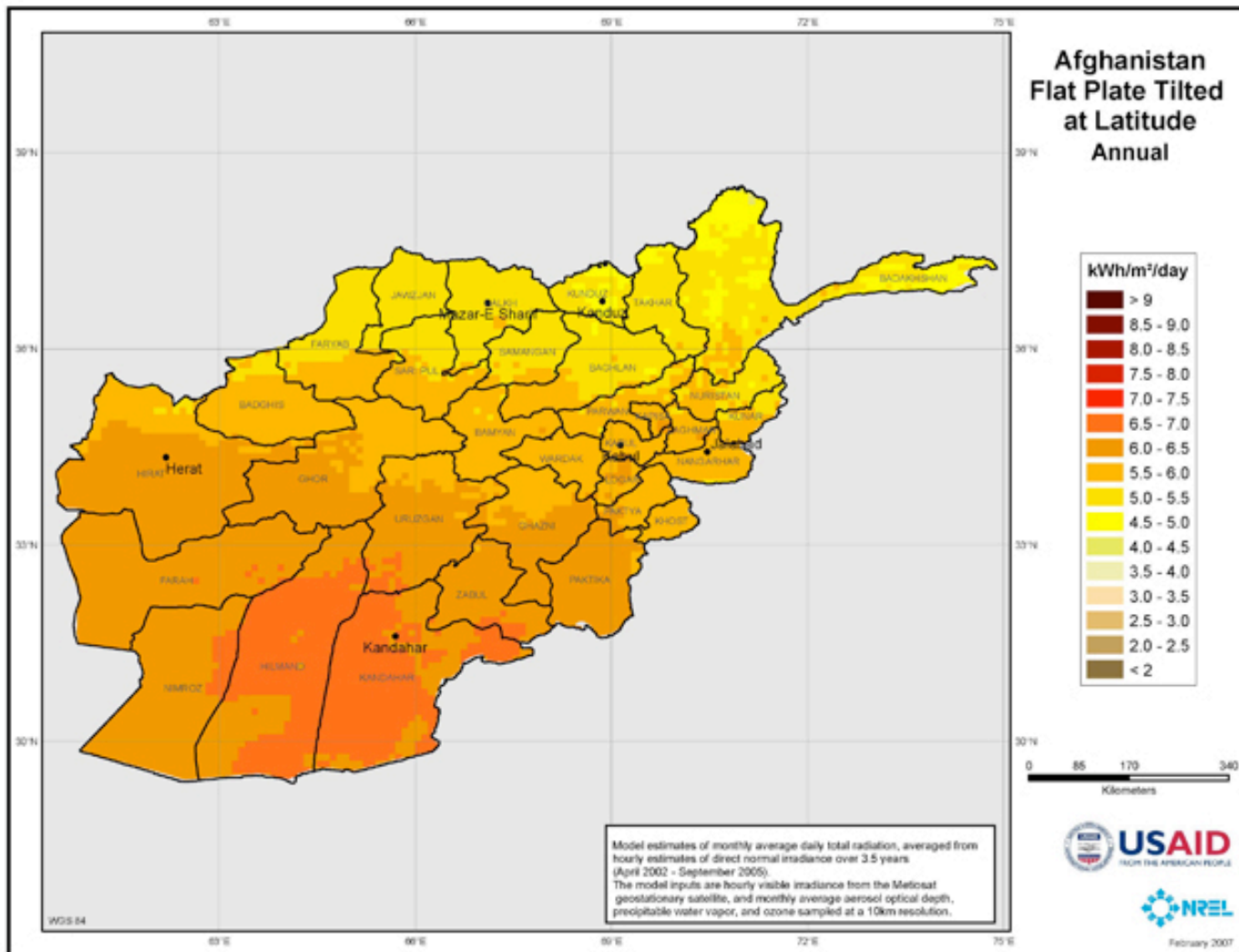


Maximum Power = 100W

Fuel



Energy from the Sun in Afghanistan



Energy and Power from the Sun in Afghanistan

Q. How much instantaneous power from the sun falls on a horizontal surface at noon in Kabul on a clear, sunny day?

A. approximately 1000-1200 W/m²

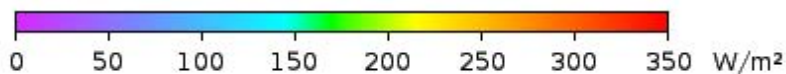
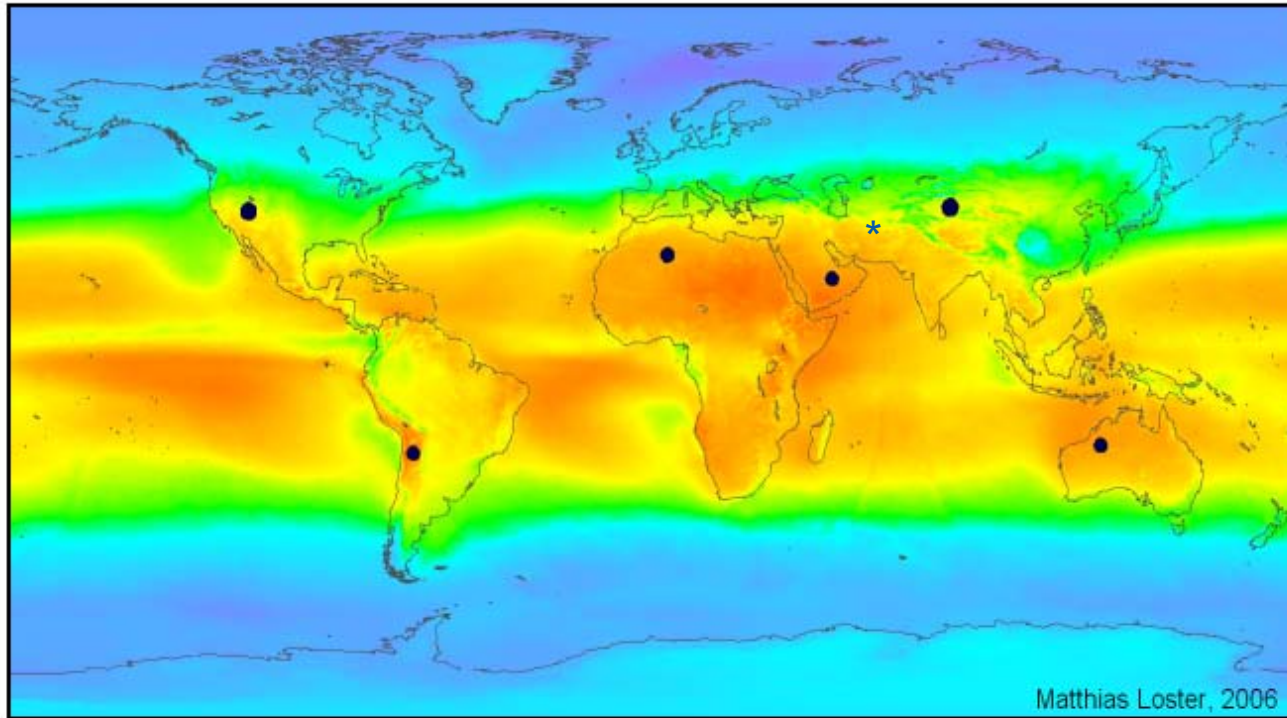
Q. How many peak sun-hours are there, per day, on average over the year?

A. About 5 peak sun-hours per day

Q. How much sun energy/day is there, on average?

A. There are, on average, about 6000 Wh, or 6 kWh of sun energy per square meter over the course of the year, more in the summer, and fewer in the winter.

Kabul Average Annual Solar Radiation: “Continuous” Power from the Sun



$\Sigma \bullet = 18 \text{ TWe}$

Q. What is the average the amount of power from the sun that shines in Kabul per m² over the whole year, day and night?

A. approximately 250 W/m²

How can we convert Solar Power to Useful Power?

Solar →→ Heat:

Using solar collectors and water storage, system efficiencies are as much as 70%.

Solar →→ Electricity:

Using PV modules connected directly to the load, system efficiencies are up to 15%. Systems with storage and inverters have efficiencies of about 10%.

How much energy and power does my application require?

Home 2 (efficient)

Appliance	Qty.	Volts	AC DC	P Y/N	Run Watts	Hours /Day	Days /Week	W-hours /Day	Percent of Total	Surge Watts	Ph-L Y/N
Fluorescent Lights	4	117	AC	Y	15	5.0	7	300.0	7.7%	0	N
Fridge Sun Frost 16 cu. ft.	1	12	DC	N	48	11.3	7	540.0	13.9%	1300	N
Blender	1	117	DC	N	350	0.1	2	10.0	0.3%	1050	N
Microwave Oven	1	117	AC	N	900	0.3	7	225.0	5.8%	1200	Y
Food Processor	1	117	AC	N	400	0.1	5	28.6	0.7%	1200	N
Espresso Maker	1	117	AC	N	1350	0.1	7	135.0	3.5%	1350	N
Coffee Grinder	1	117	AC	N	150	0.1	7	7.5	0.2%	200	N
21" Color Television	1	117	AC	Y	125	5.0	7	625.0	16.0%	570	Y
Video Cassette Recorder	1	117	AC	Y	40	2.5	7	100.0	2.6%	80	Y
Satellite TV System	1	117	AC	Y	60	2.5	7	150.0	3.8%	1600	Y
Stereo System	1	117	AC	Y	30	8.0	7	240.0	6.2%	60	Y
Computer	1	117	AC	Y	45	6.0	3	115.7	3.0%	135	Y
Computer Printer	1	117	AC	N	120	0.3	3	12.9	0.3%	360	Y
Power Tool	1	117	AC	N	750	0.5	3	160.7	4.1%	2250	N
Radio Telephone (receive)	1	12	DC	N	6	24.0	7	144.0	3.7%	0	N
Radio Telephone (transmit)	1	12	DC	N	20	1.0	7	20.0	0.5%	0	N
Phone Answering Machine	1	117	AC	Y	6	24.0	7	144.0	3.7%	0	N
Washing Machine	1	117	AC	N	800	0.5	4	228.6	5.9%	100	Y
Clothes Dryer (motor only)	1	117	AC	N	500	1.0	4	285.7	7.3%	1500	Y
Sewing Machine	1	117	AC	N	80	2.0	1	22.9	0.6%	400	N
Vacuum Cleaner	1	117	AC	N	650	0.5	4	185.7	4.8%	1950	N
Hair Dryer	1	117	AC	N	1000	0.2	7	200.0	5.1%	1500	N
Ni-Cd Battery Charger	1	117	AC	Y	4	15.0	2	17.1	0.4%	25	Y

Total Daily Average Watt-hrs 3898.4

Inverter Priority Wattage 325

Max. ac Wattage 1350

Max. ac Surge Wattage

2250

Who?

-Who chooses and buys the candles, kerosene, and wood in the household?

-Who chooses and buys the light bulbs and the batteries for the household?

-Who takes the children to the health clinic when they are sick?

-In short, who makes the energy-buying decisions in the household?

* * * * *

-All energy sources come with a cost. You have a choice!

Coming up next in this series:

Introduction to solar technology, including:
Solar water heating, and
Photovoltaics (PV)



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