Sustainable electric energy supply by decentralized alternative energy technologies

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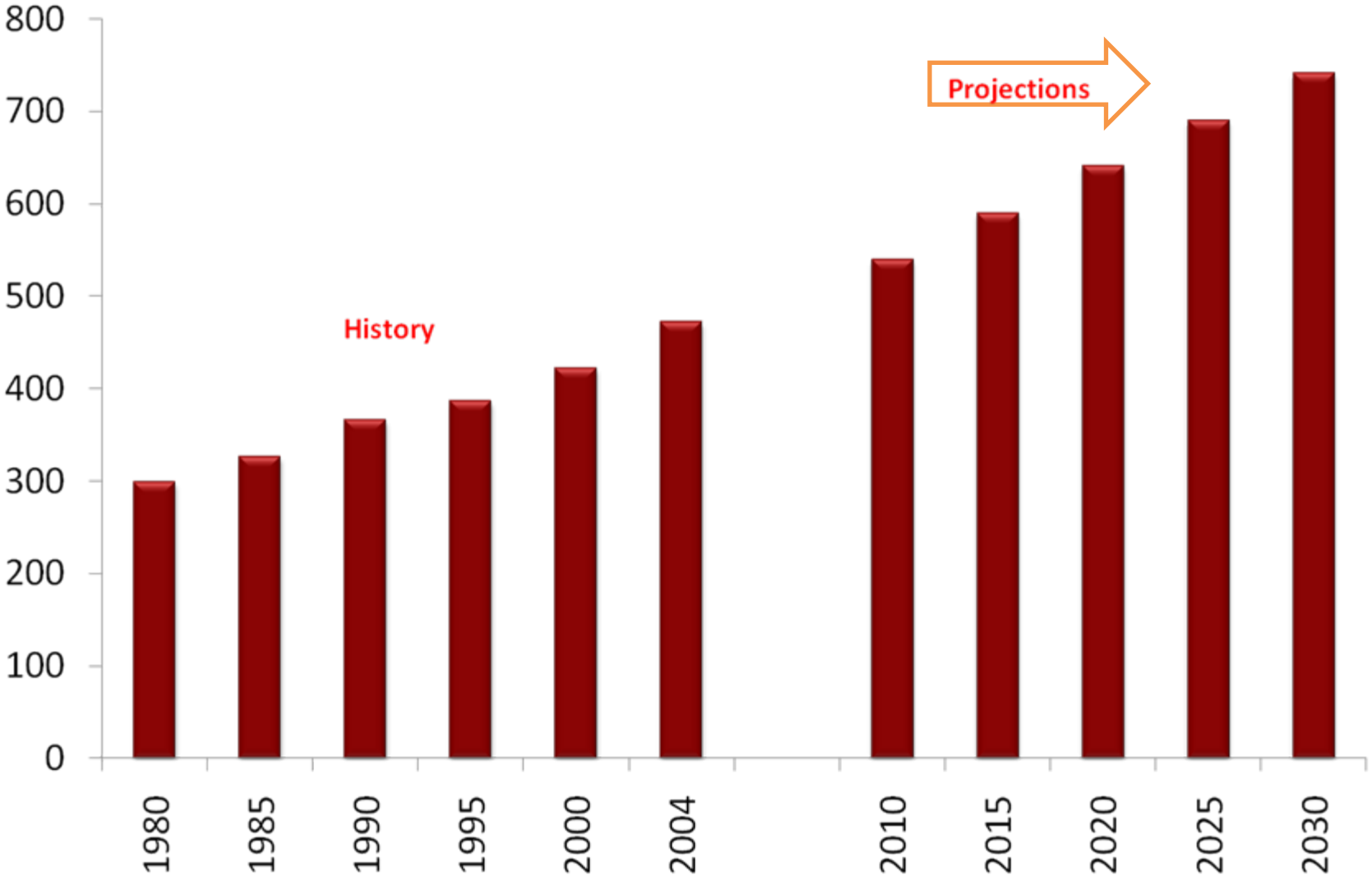
6. Presentations by A/Prof Lovegrove & I McLeod Ergon Energy CEO
7. Electricity Supply Association of Australia (ESAA)
8. Organization of Petroleum Exporting Countries (OPEC)
9. Paul Gipes, Wind Energy Comes of Age
10. Global Wind Energy Council
11. Australian Clean Energy Council
12. Australian PV Association (APVA)

Introduction

World energy demand in TJ (10^{12} Joules) (Source: EIA)



Worldwide demand for energy is increasing. To respond to this demand increase, the world either has to build more power plants of current technologies or to discover new sources of energy or to develop new energy technologies.

Current main Energy sources:

*Oil**

*Coal**

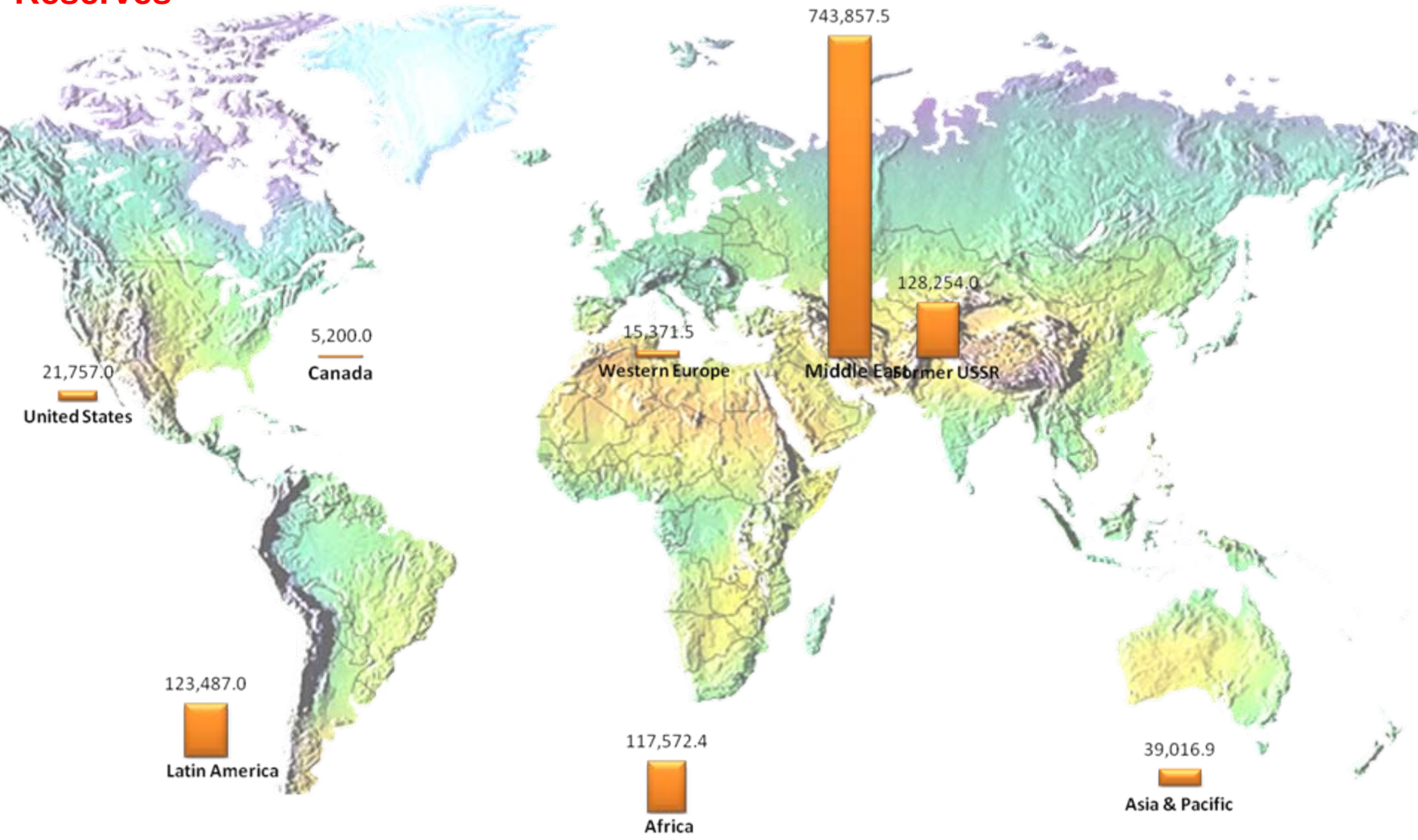
*Gas**

Nuclear

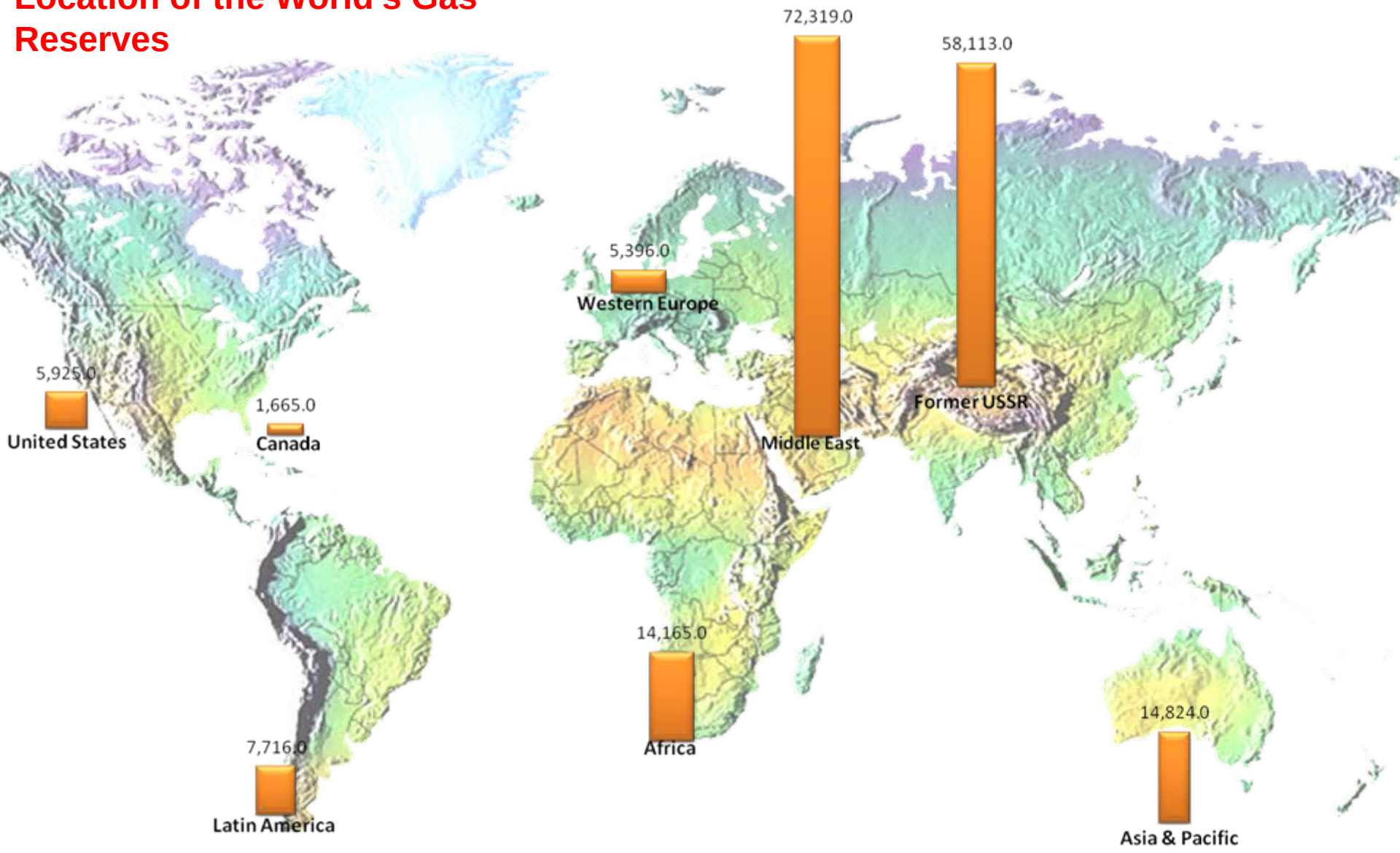
Non-renewable sources

**Global Climate Changes*

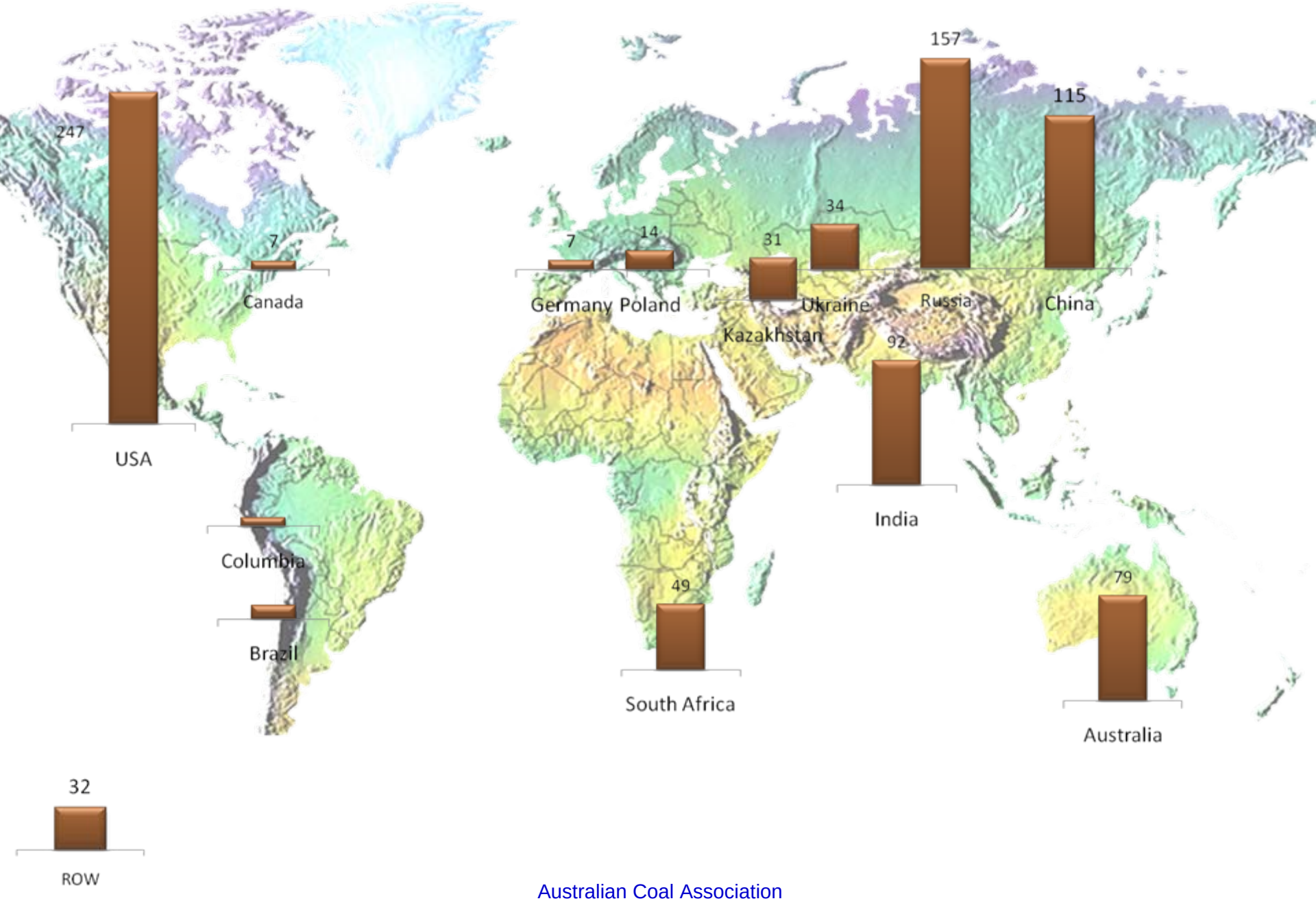
Location of the World's Oil Reserves



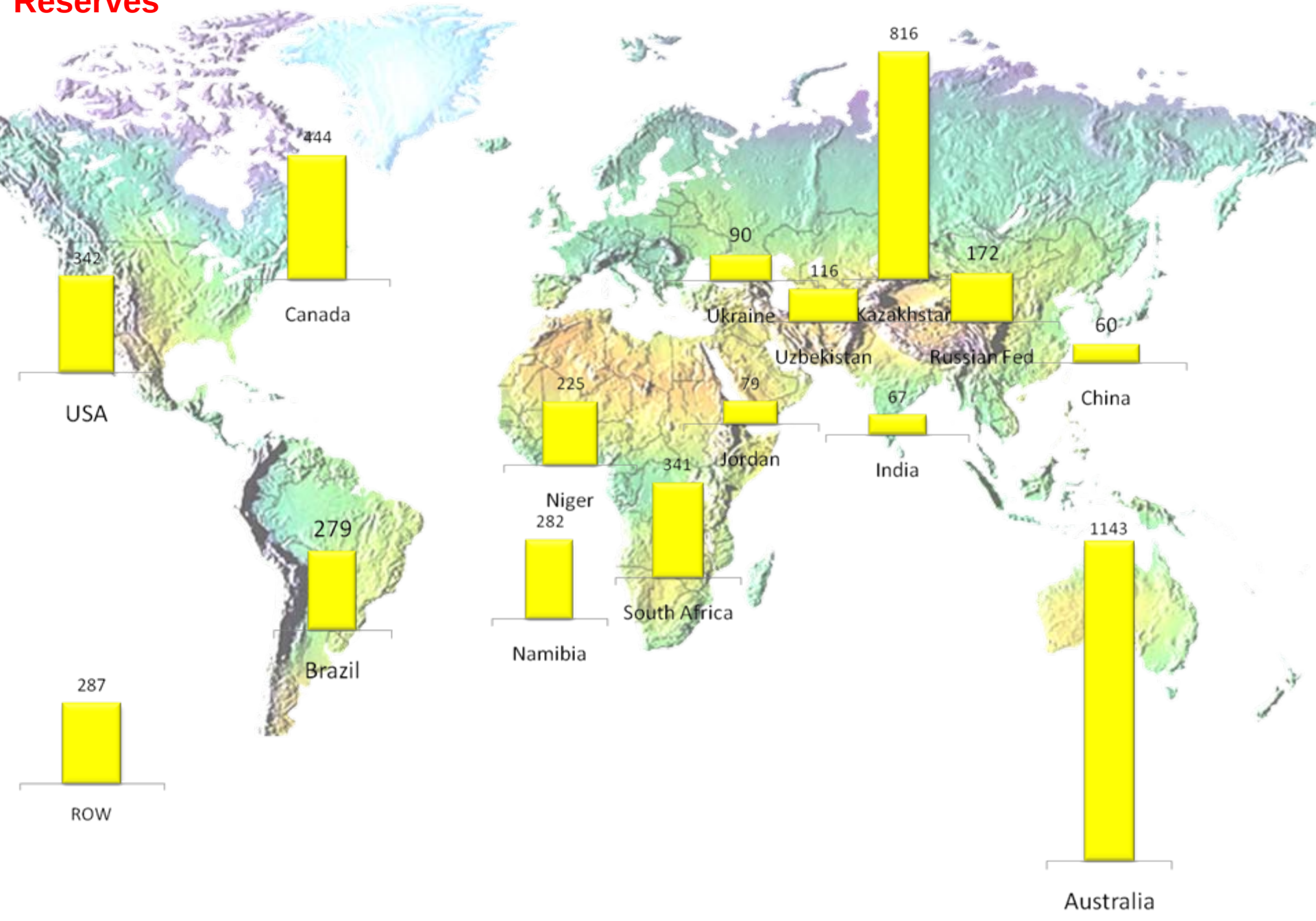
Location of the World's Gas Reserves



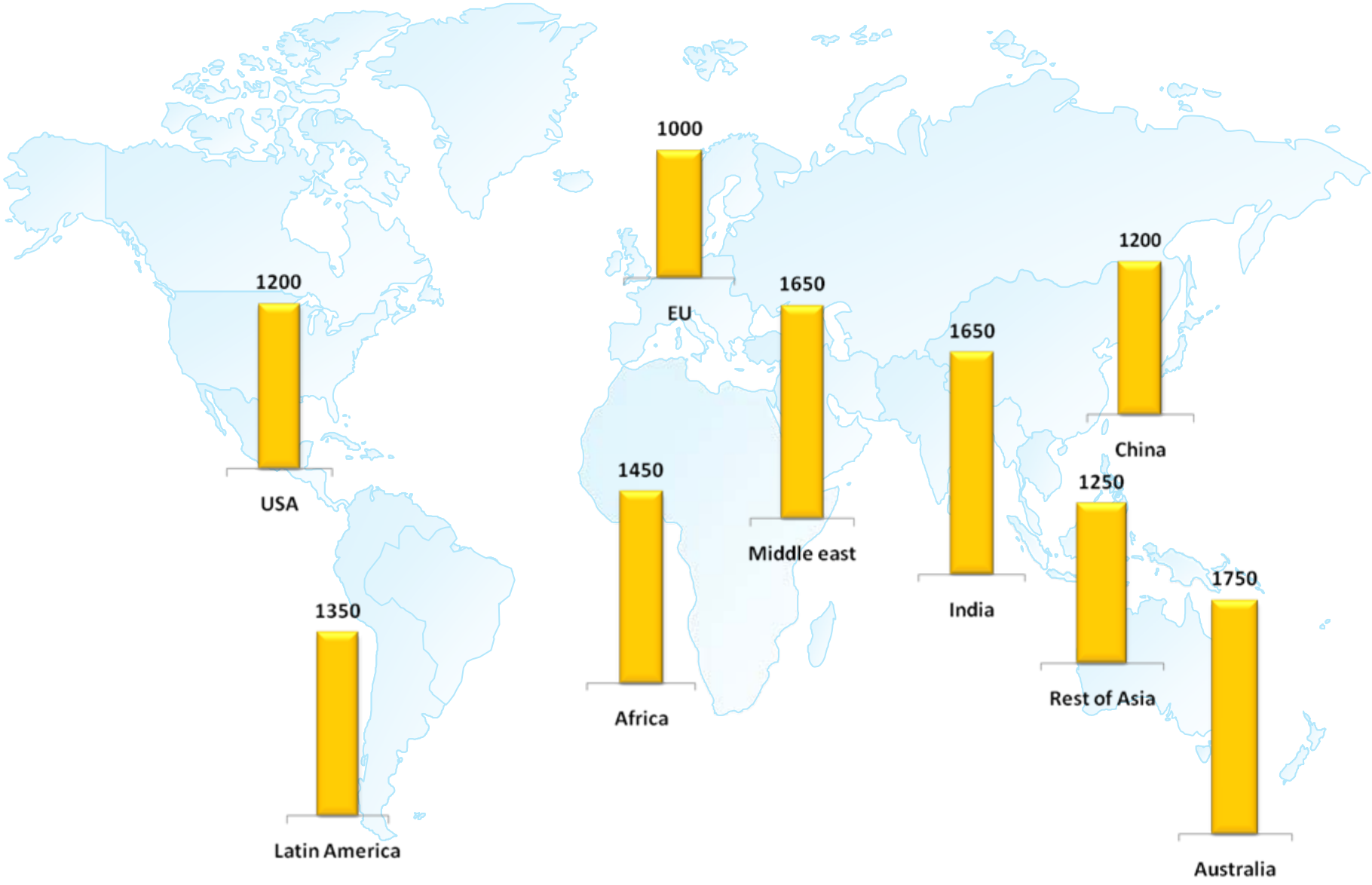
Location of the World's Main Coal Reserves



Location of the World's Main Uranium Reserves

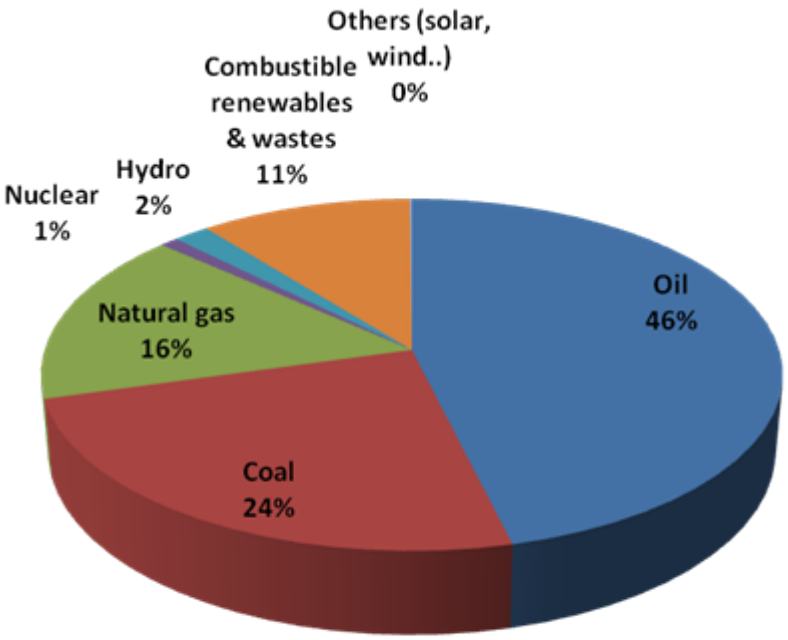


World's sun radiation kWh/m^2/year

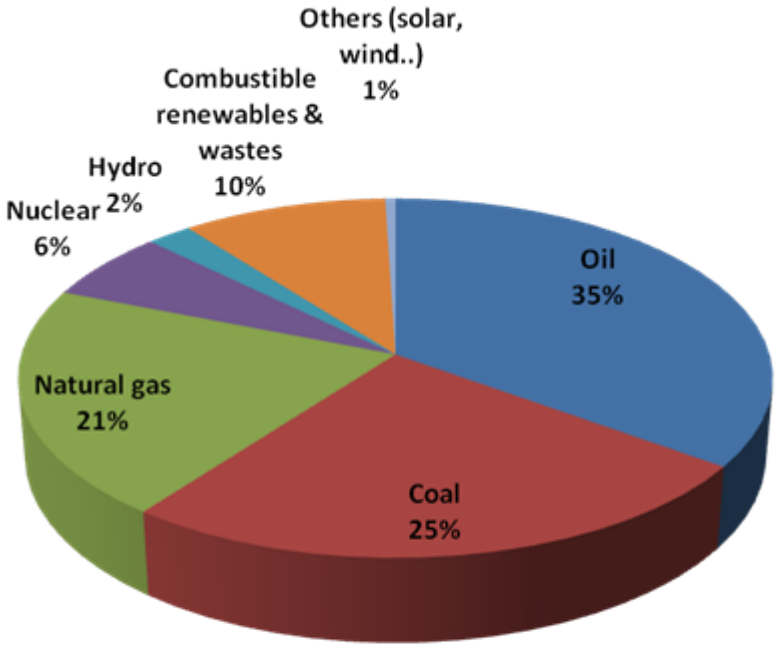


CSIRO

How fast are we using them?

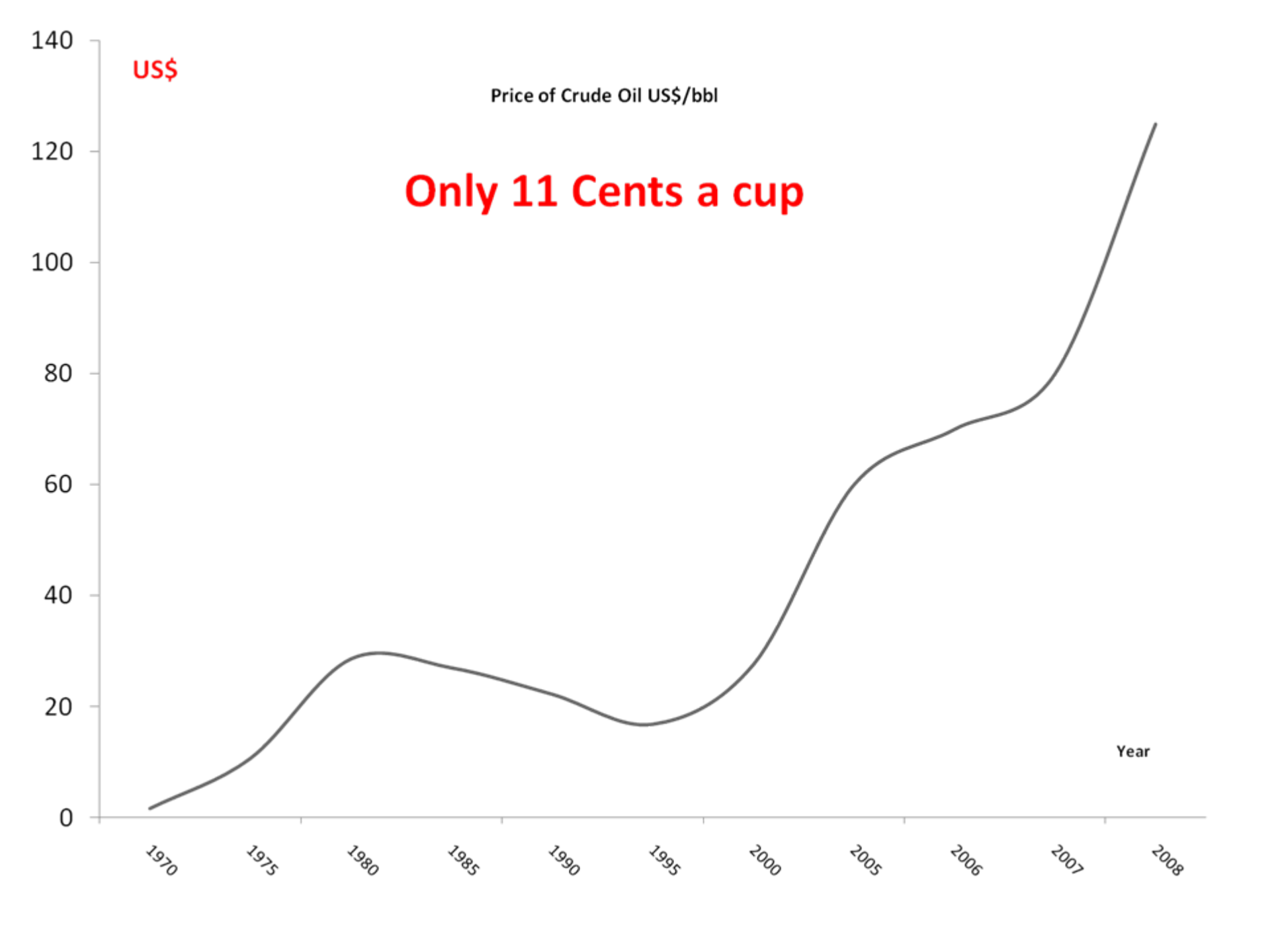


1973, Total: 260 EXA Joules

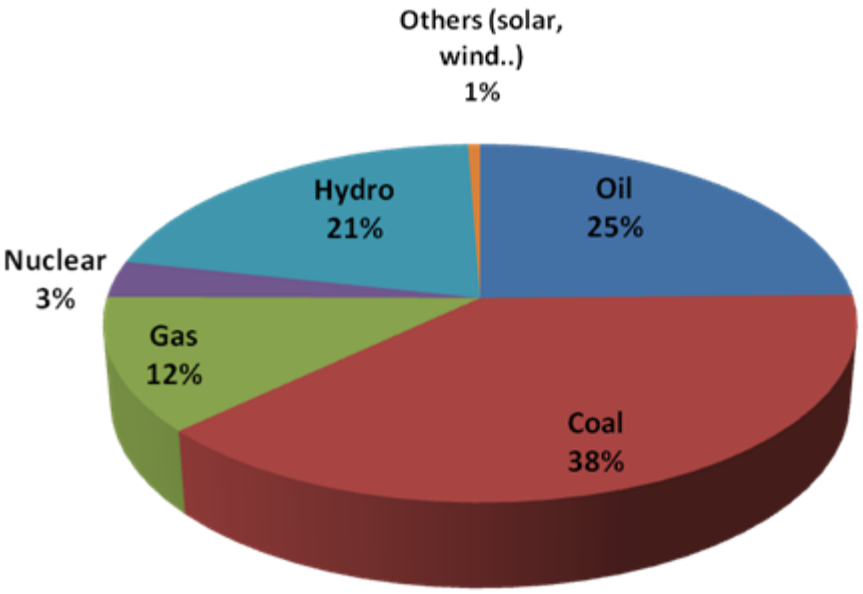


2005, Total: 480 EXA Joules

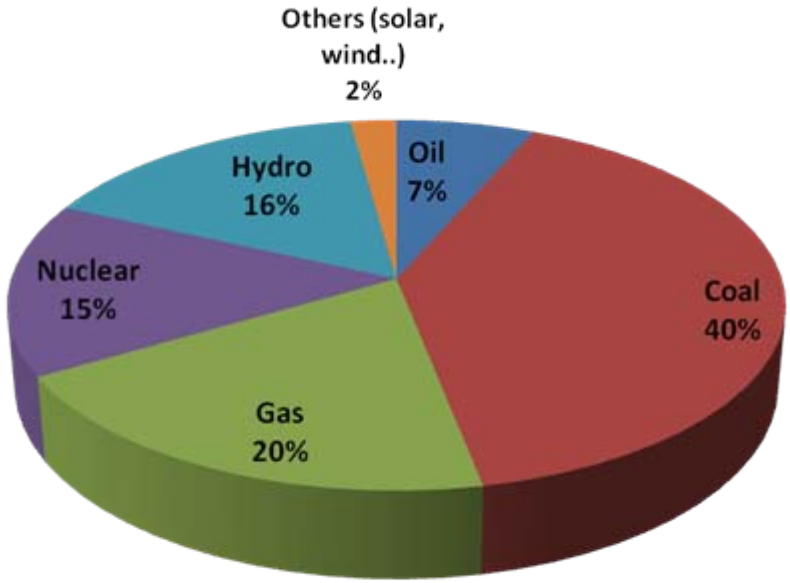
End-use energy consumption, by Fuel Shares (IEA)


US$
Price of Crude Oil US$/bbl
Only 11 Cents a cup
140
120
100
80
60
40
20
0
Year
1970
1975
1980
1985
1990
1995
2000
2005
2006
2007
2008

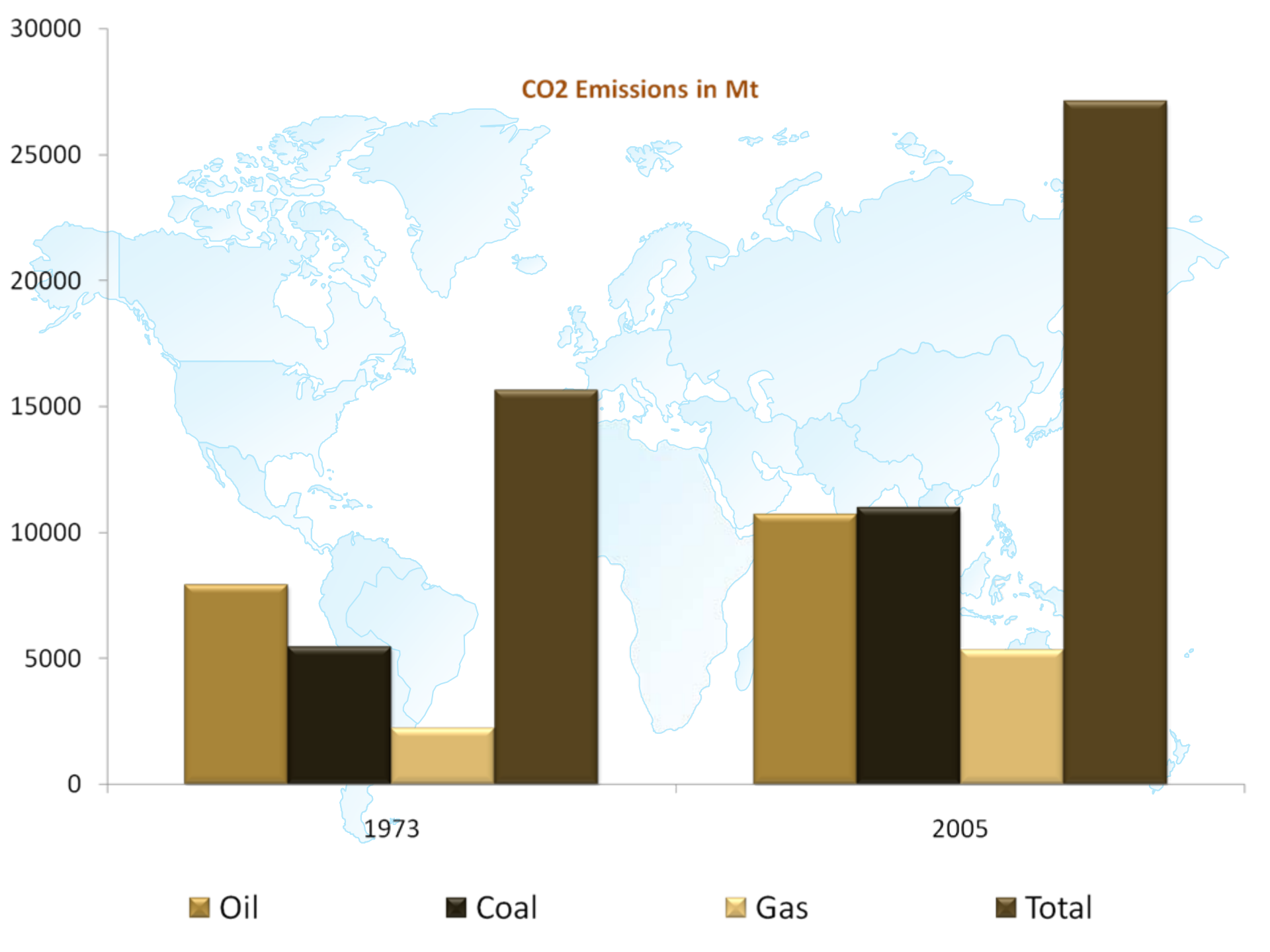
World Electricity generation by fuel (IEA)



1973, Total: 6116 TWh (10^{12}Wh)



2005, Total: 18235 TWh


CO2 Emissions in Mt
30000
25000
20000
15000
10000
5000
0
1973
2005
Oil
Coal
Gas
Total

Can Nuclear energy help?

Technical, Safety, social issues, hard to convince public

Nuclear power is low-carbon source of electricity
Nuclear power can help reduce dependence in imported other fuels such as oil & gas;

Unlike oil & gas , uranium resources are widely distributed around the world;

Nuclear power plants produce electricity at relatively stable cost, because the **cost of fuel** represents about **15% of the production cost.**

In gas-fired PP, **cost of fuel is about 75%** of the production cost

Nuclear power, a proven technology for base-load electricity generation, could make a significant contribution to reducing GHG emissions

368 GW in 2005, 16%
416 GW in 2030, 10%

(52 New Reactors by 2030)

Reasoning:

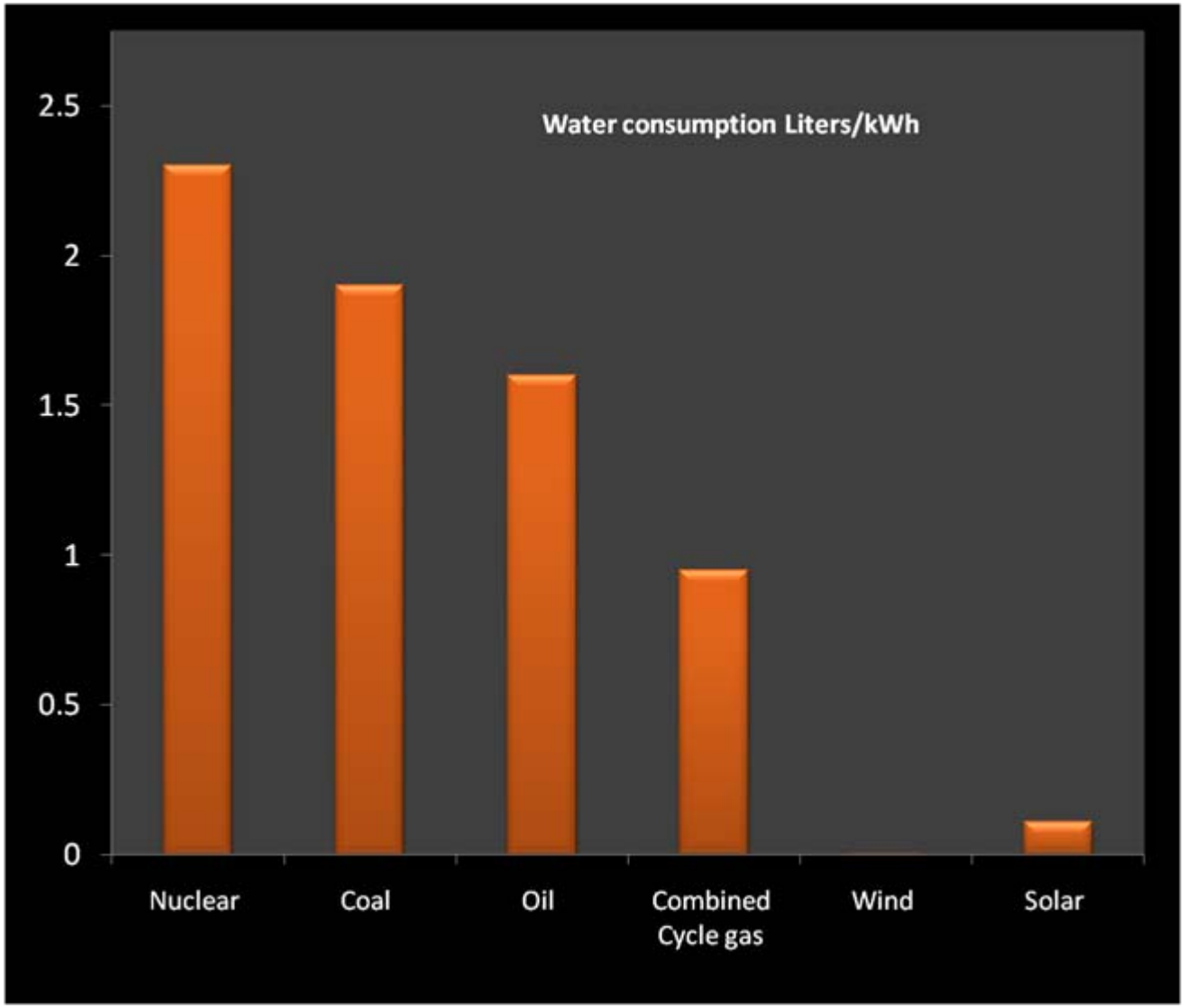
Capital intensive, $2 - $3.5 bill/Reactor
Energy intensive, 10-11 times
It takes about 10 years to build a new NPP

Economics is not the only factor determining construction of new NPP;

Safety, Nuclear waste disposal, the risk of proliferation are real challenges which have to be solved to the satisfaction of the public

Water Consumption--Conventional Power Plants, Water shortage ?

Technology	Liters/ kWh
Nuclear	2.3
Coal	1.9
Oil	1.6
Combined Cycle gas	0.95
Wind	0.004
Solar	0.110



According to the California Energy Commission
(cited in **Paul Gipe's** Wind Energy Comes of Age, John Wiley & Sons, 1995)

Uranium, World: 1962 kt,

Uranium, Australia: 716 kt (36.5%)

(Source: CSIRO)

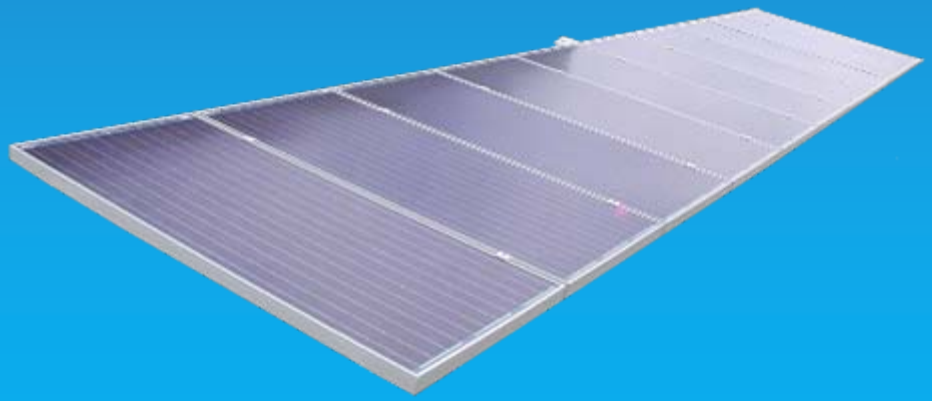
8 – 10 kt of enriched uranium is needed every year

(Source: IAEA)

NOT SUSTAINABLE

Experts believe that the uranium reserves will be finished in about four decades;
Fast Breeder Reactors: longer but extremely expensive

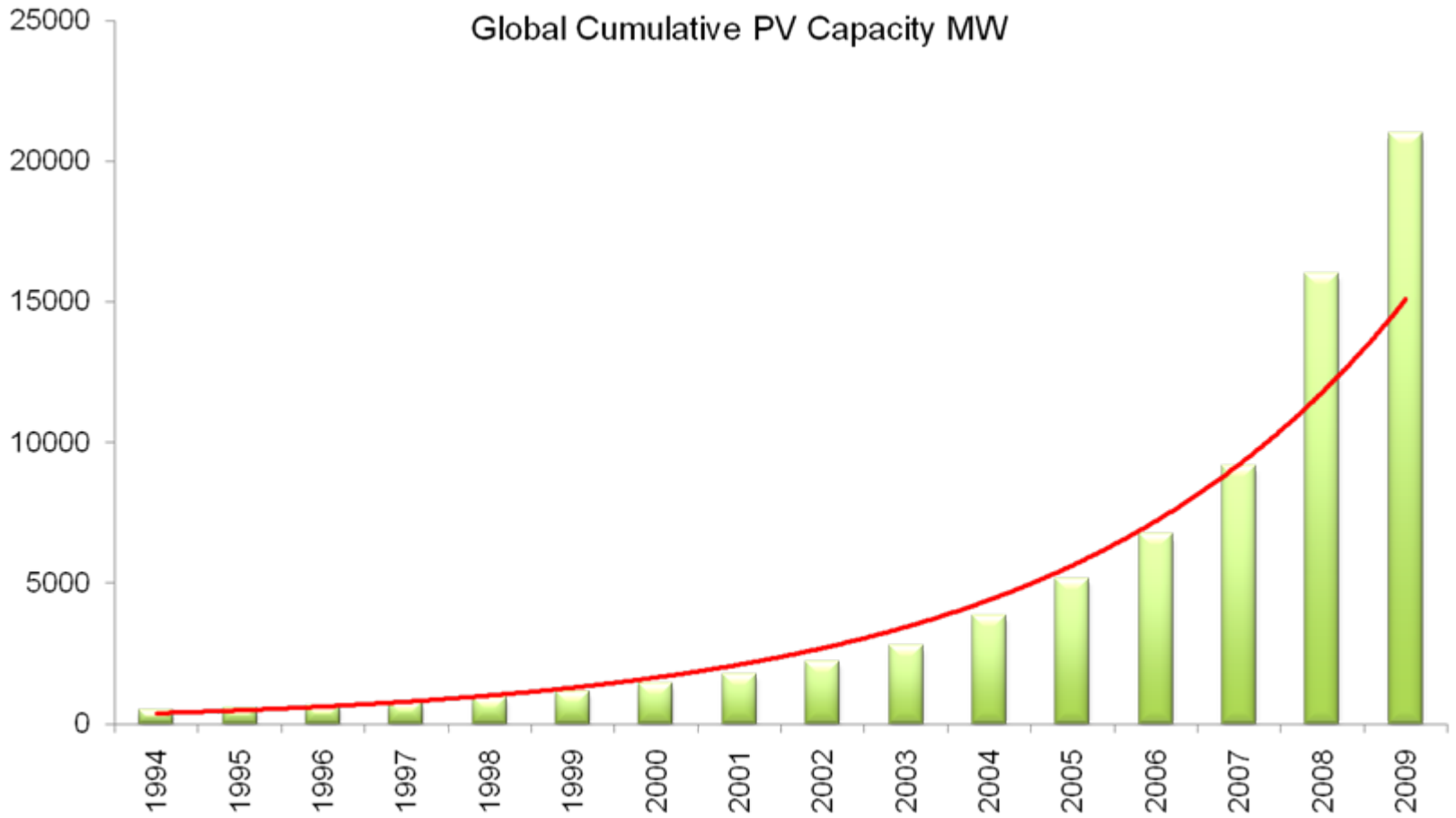
What makes Solar Energy special?



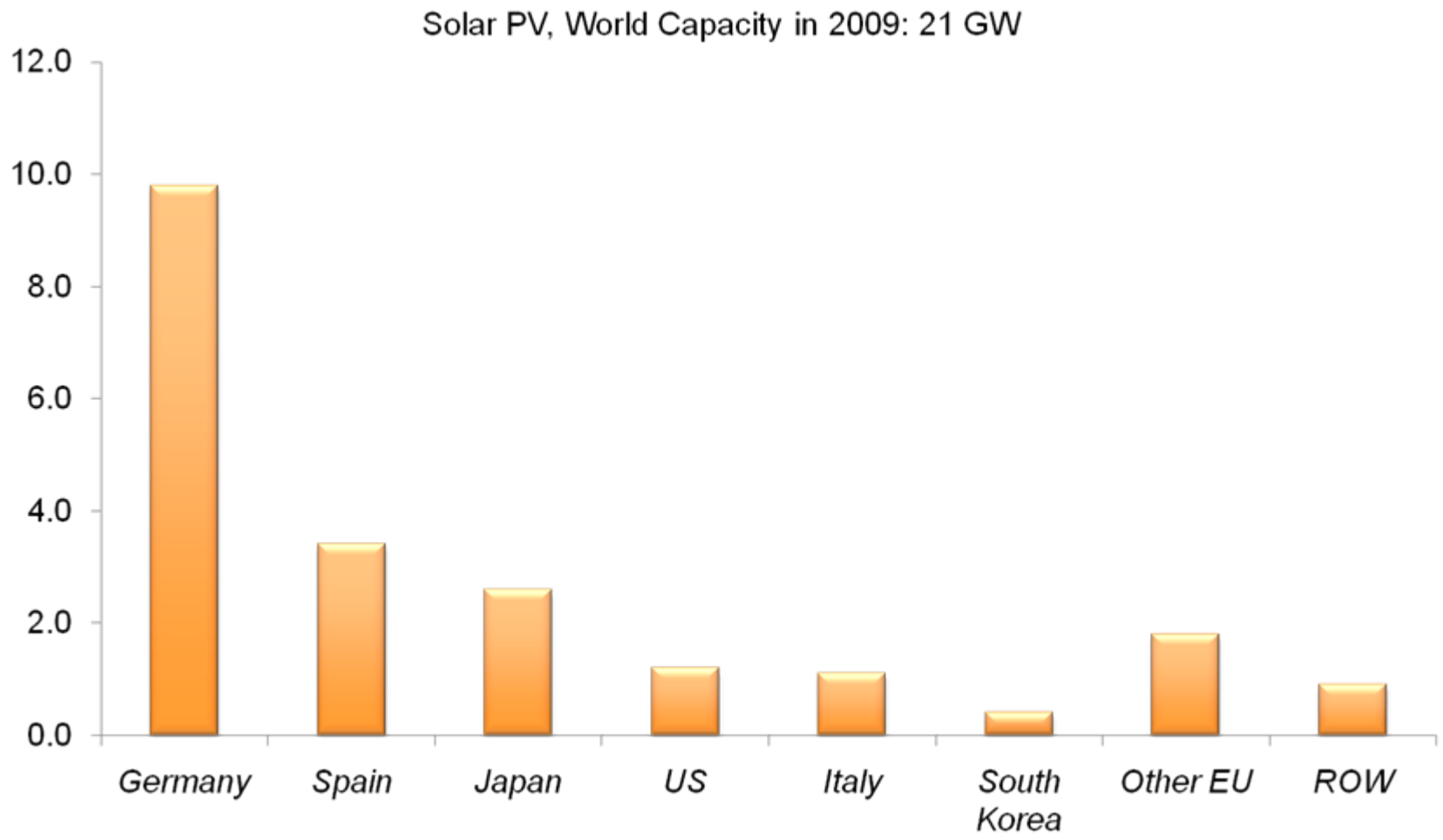
Solar energy

- ✓ **Solar energy is sustainable**
- ✓ **Solar energy technologies use only ordinary materials**
- ✓ **Solar energy uses a resource that is far larger than required to provide all of the world's energy**
- ✓ **Unlike nuclear, solar energy has no security and military risks**
- ✓ **Unlike oil & gas, solar energy is available almost everywhere**
- ✓ **Unlike fossil fuels, solar energy has minimal environmental impacts**
- ✓ **Solar is the most democratic energy technology**
- ✓ **The sun does not send a bill each month**
- ✓ **No increases in the cost of fuel**
- ✓ **No negative consequences for the environment**
- ✓ **Routine maintenance is far less than conventional plants**
- ✓ **The fuel does not have to be transported**

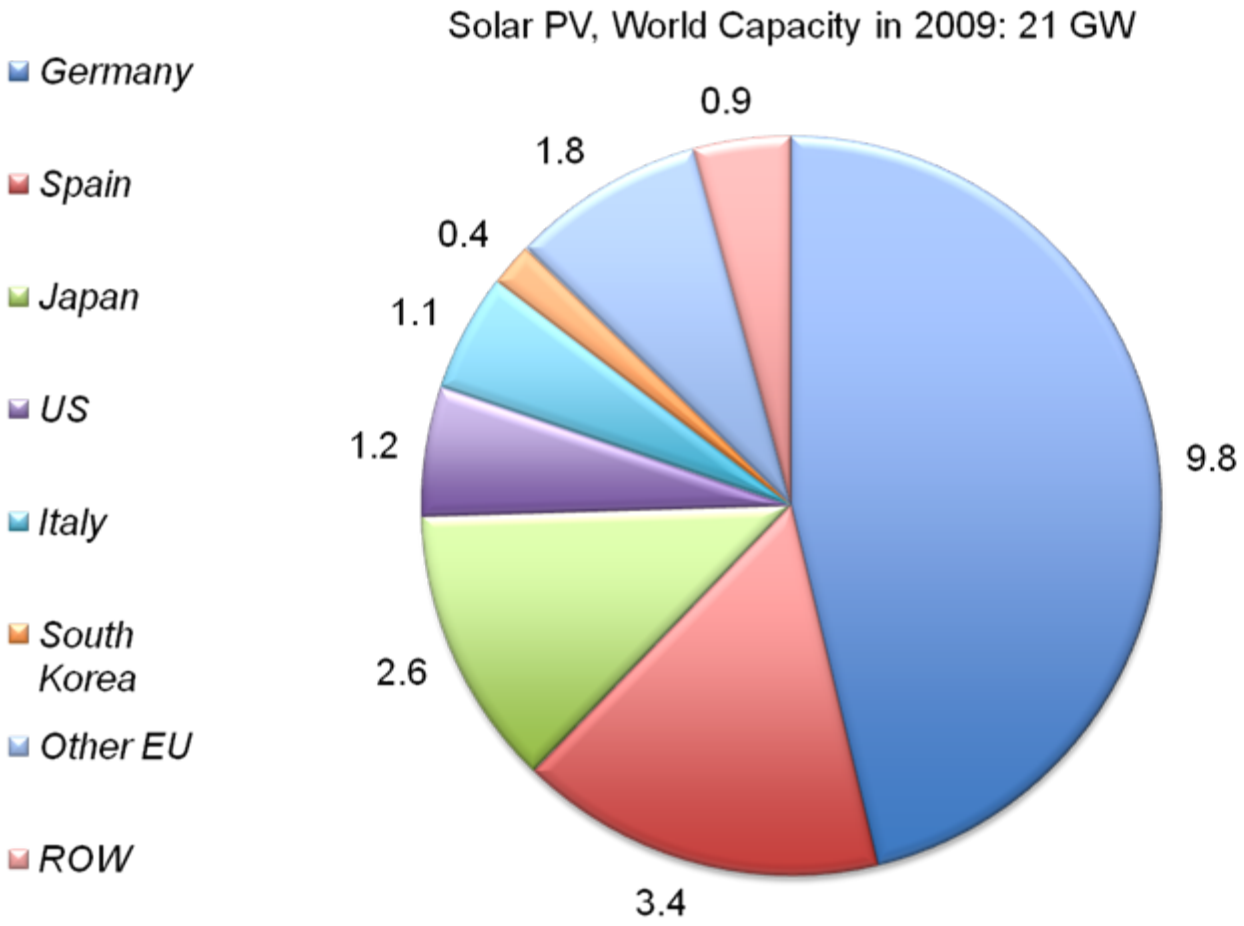
Solar PV


Global Cumulative PV Capacity MW
25000
20000
15000
10000
5000
0
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009

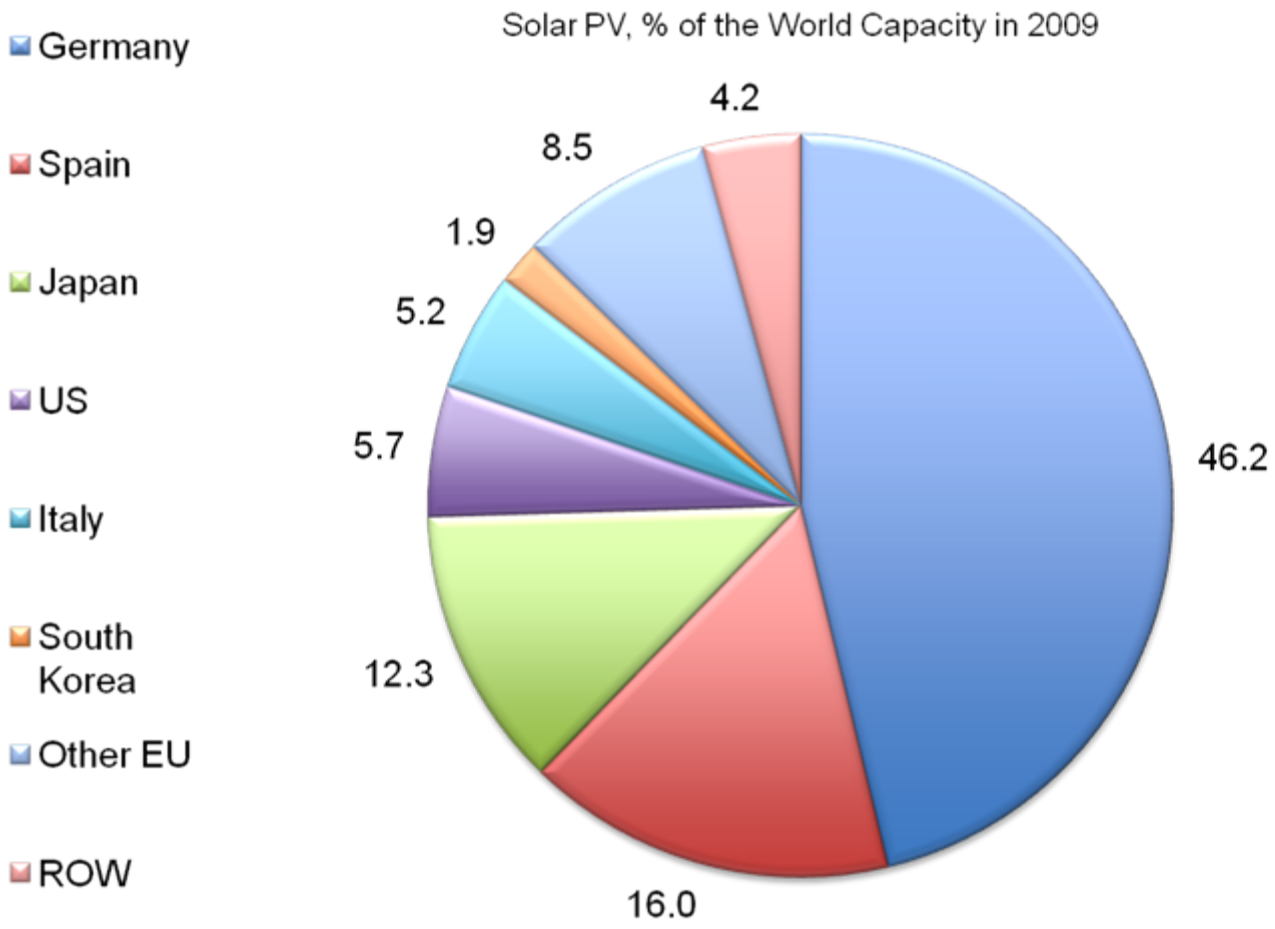
Solar PV


Solar PV, World Capacity in 2009: 21 GW
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Germany
Spain
Japan
US
Italy
South Korea
Other EU
ROW

Solar PV

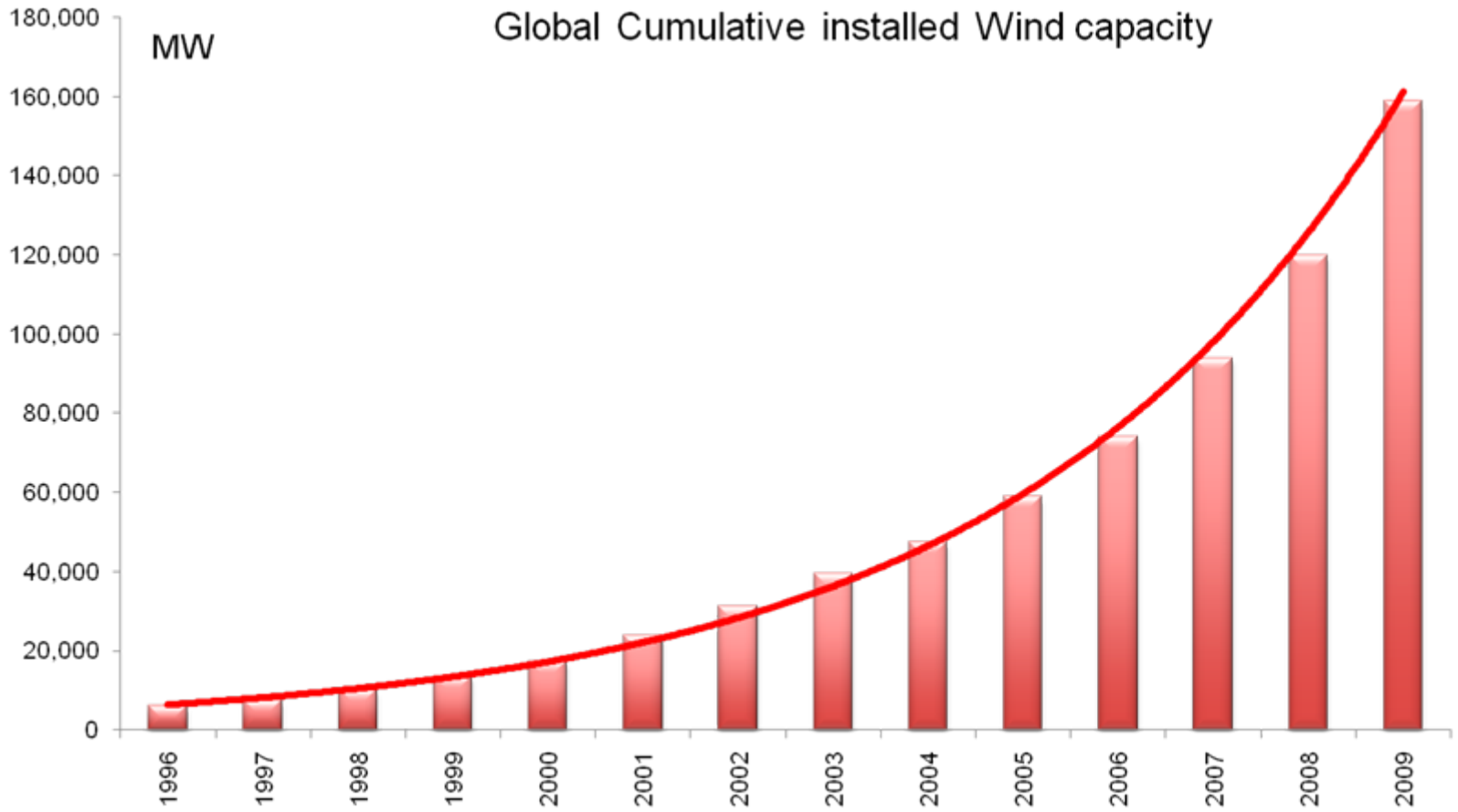

Solar PV, World Capacity in 2009: 21 GW
Germany
Spain
Japan
US
Italy
South Korea
Other EU
ROW
0.9
1.8
0.4
1.1
1.2
2.6
3.4
9.8

Solar PV

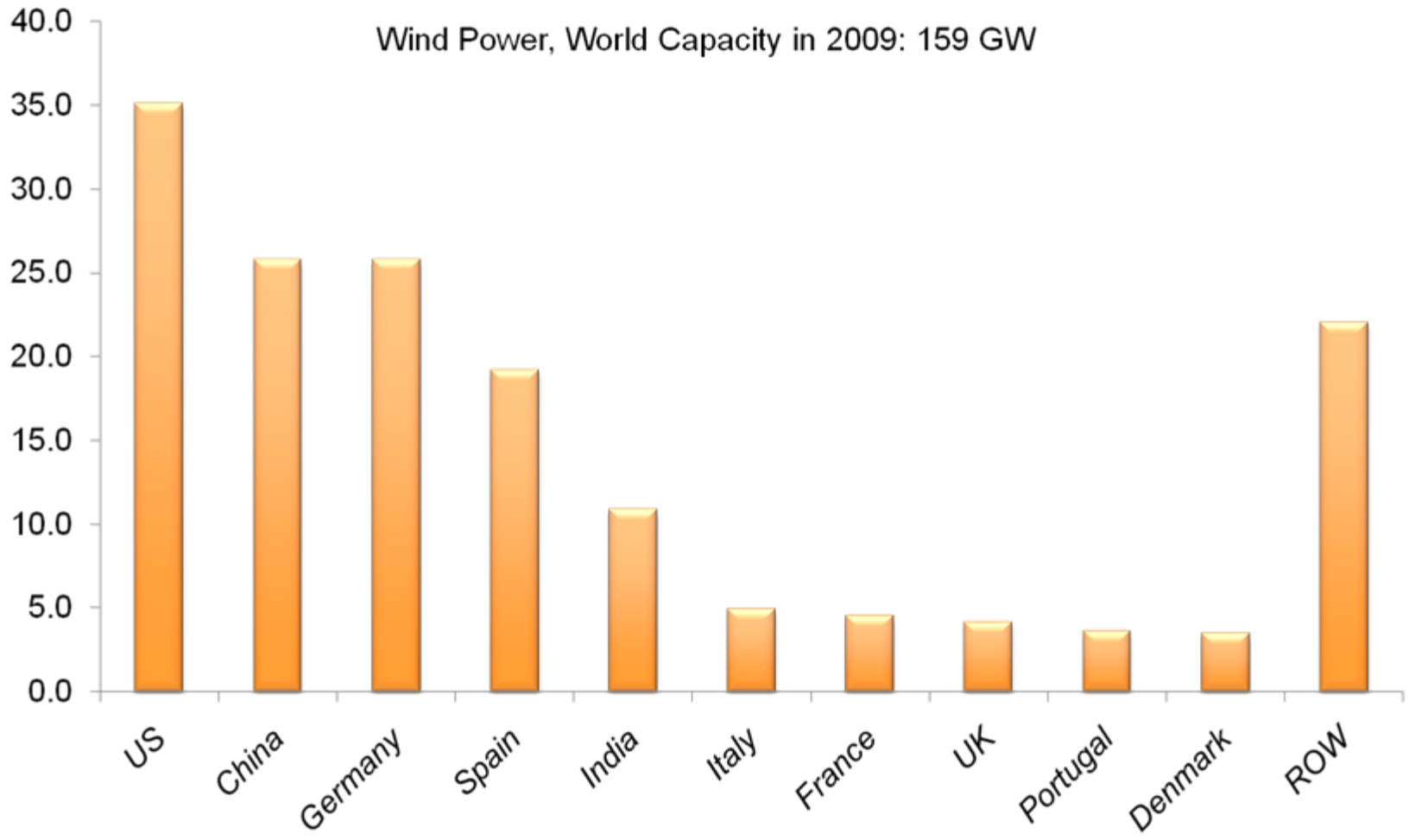

Solar PV, % of the World Capacity in 2009
Germany
Spain
Japan
US
Italy
South Korea
Other EU
ROW
4.2
8.5
1.9
5.2
5.7
46.2
12.3
16.0

Wind Power

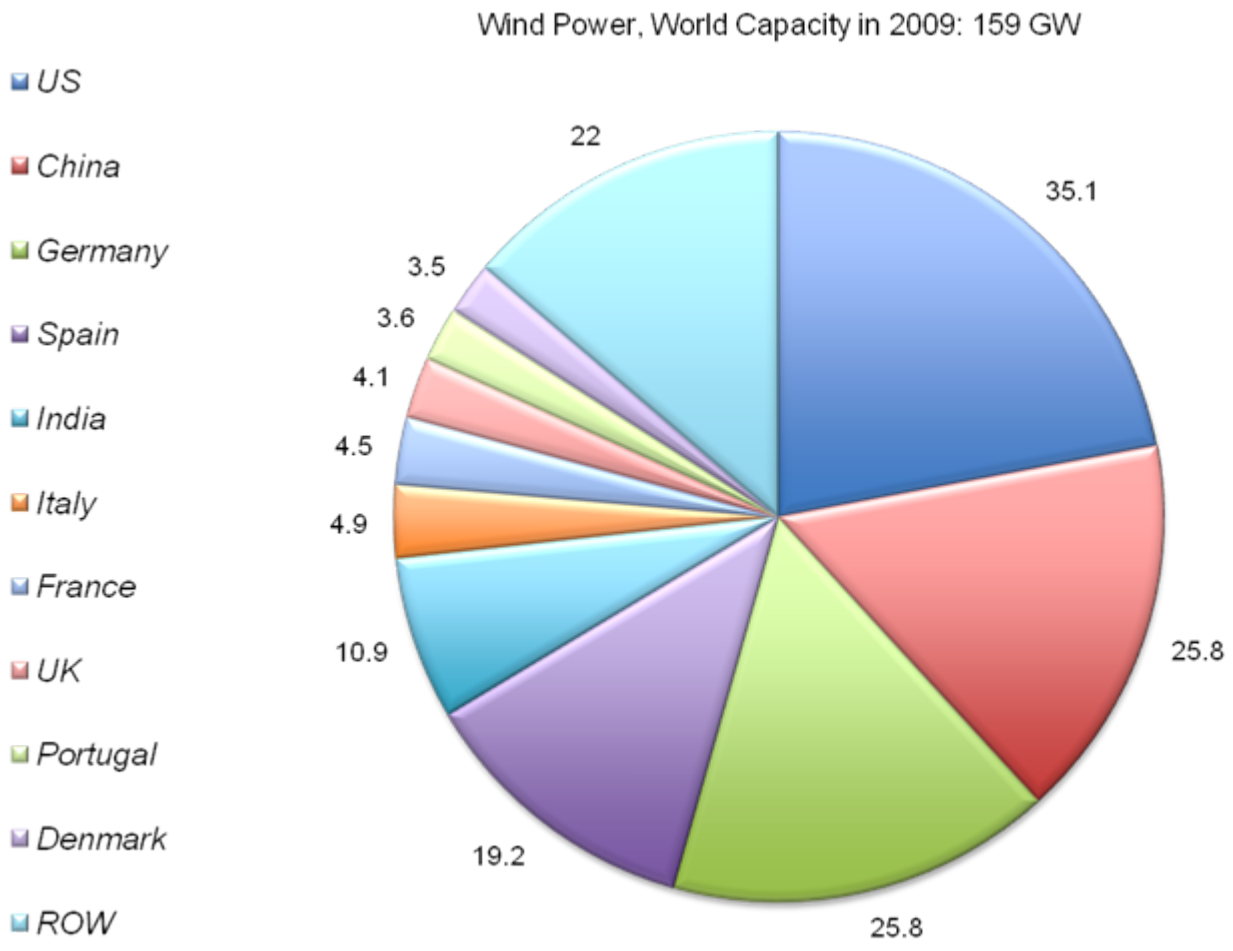
Wind power


Global Cumulative installed Wind capacity
MW
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009

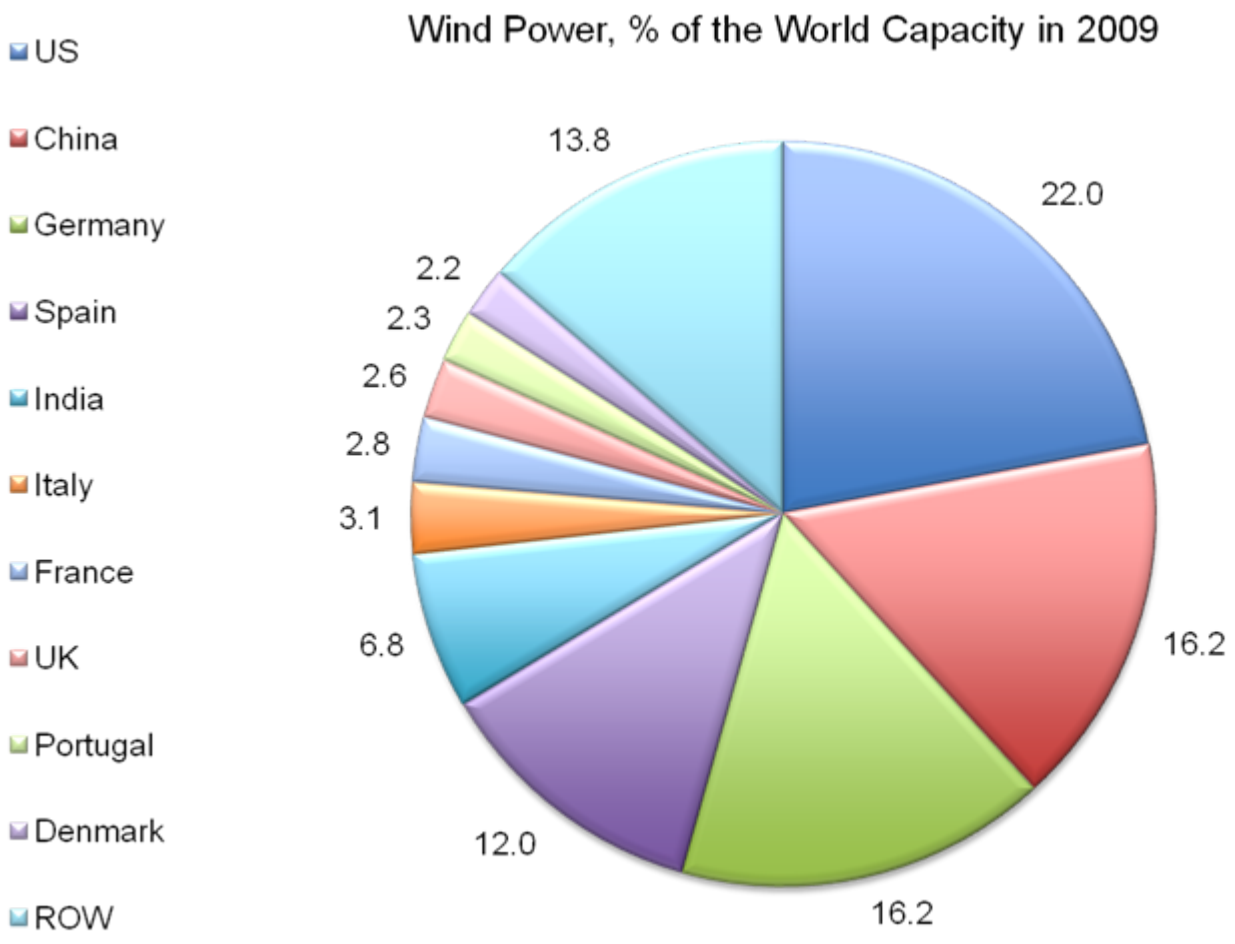
Wind power


Wind Power, World Capacity in 2009: 159 GW
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
US
China
Germany
Spain
India
Italy
France
UK
Portugal
Denmark
ROW

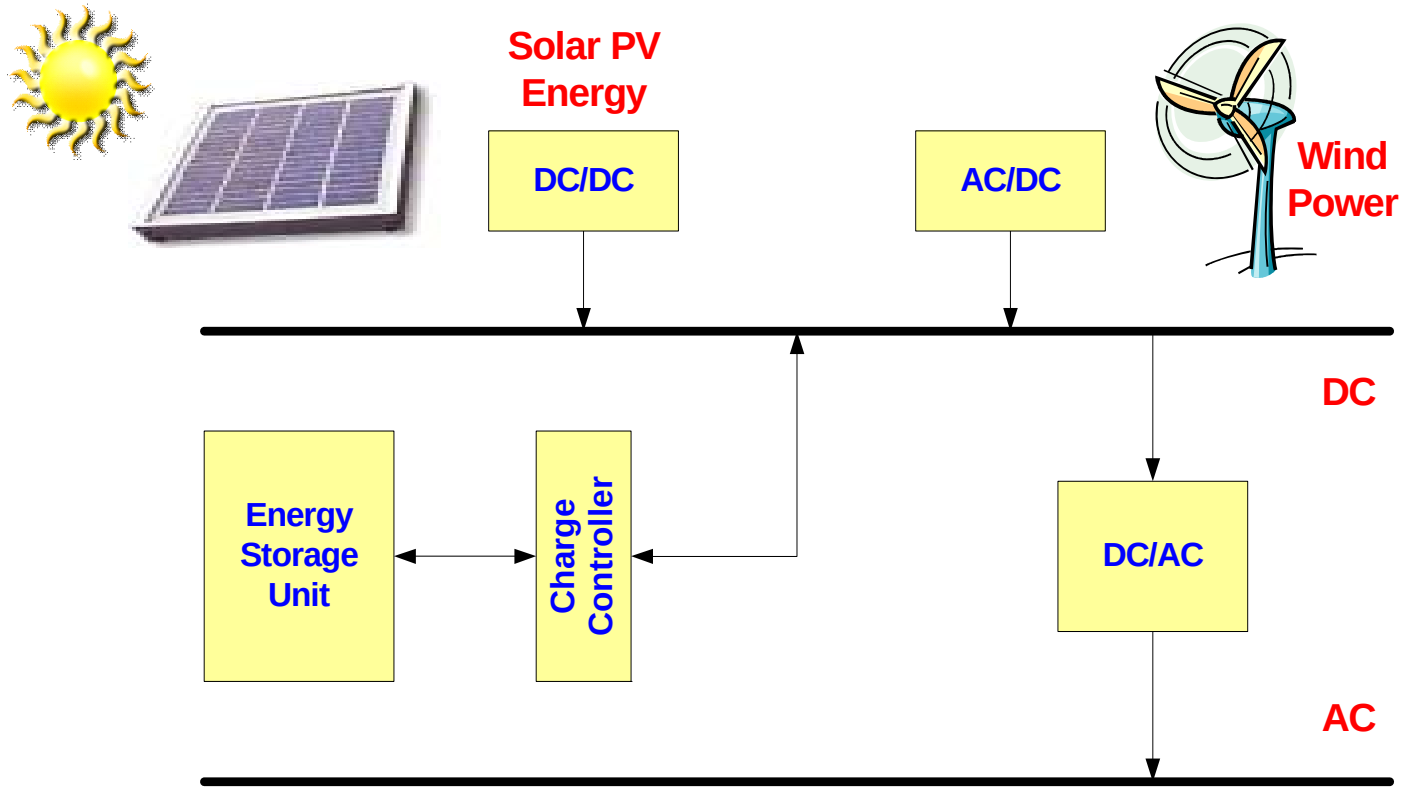
Wind power


Wind Power, World Capacity in 2009: 159 GW
US
China
Germany
Spain
India
Italy
France
UK
Portugal
Denmark
ROW
35.1
25.8
25.8
19.2
10.9
4.9
4.5
4.1
3.6
3.5
22

Wind power


Wind Power, % of the World Capacity in 2009
US
China
Germany
Spain
India
Italy
France
UK
Portugal
Denmark
ROW
22.0
16.2
16.2
12.0
6.8
3.1
2.8
2.6
2.3
2.2
13.8

Hybrid


Solar PV Energy
DC/DC
AC/DC
Wind Power
DC
Energy Storage Unit
Charge Controller
DC/AC
AC

Hybrid

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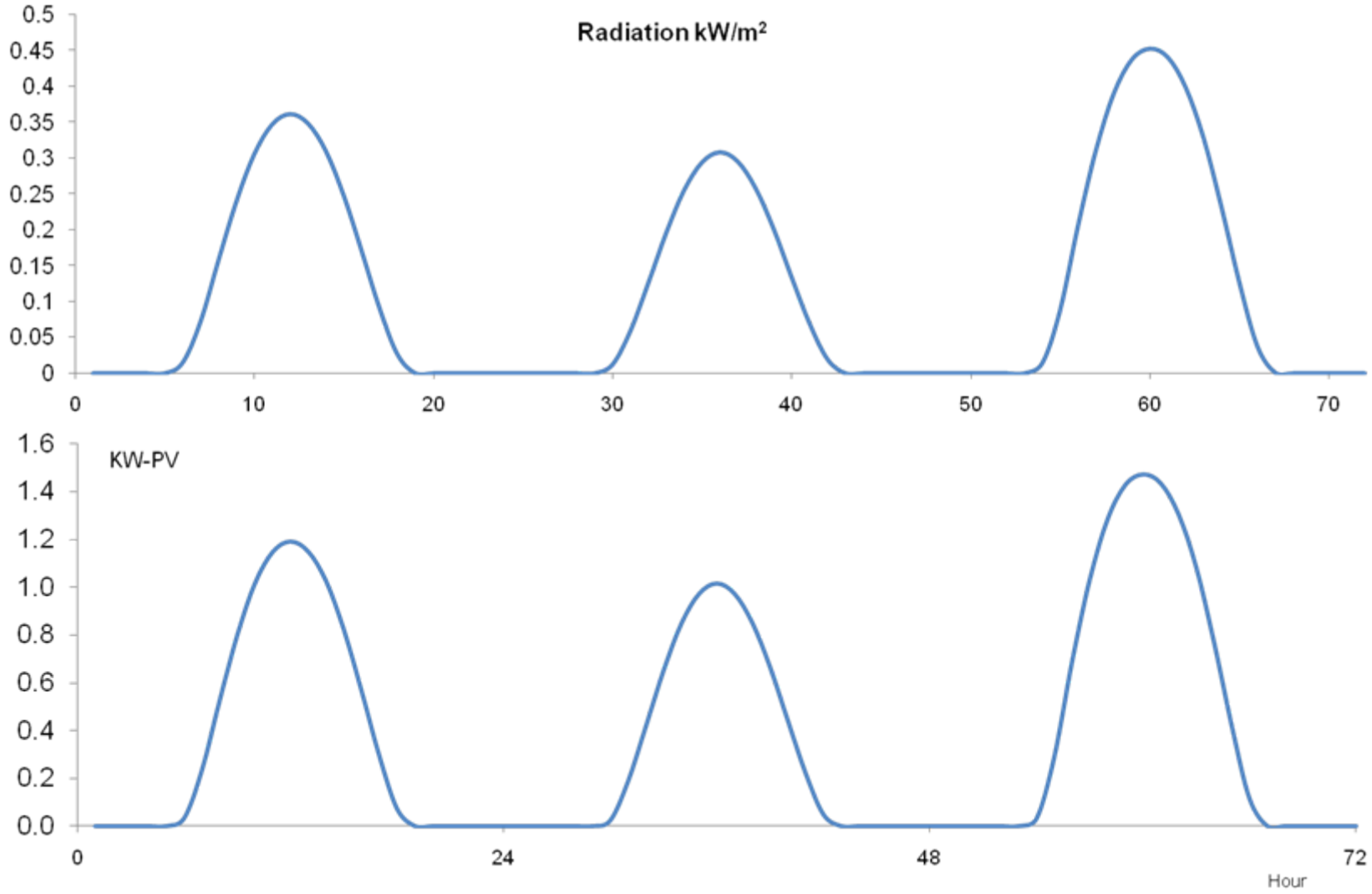
# of WT	Rated WT	Eff. WT	Air Density	Radius, m	WS, m/s	Old H
1	330	0.45	1.05	10	6.25	10
New H	Roughness	De-Rating	PV-kW	Load/day	Efficiency	Storage
20	0.15	0.85	325	2650	0.85	300MWh

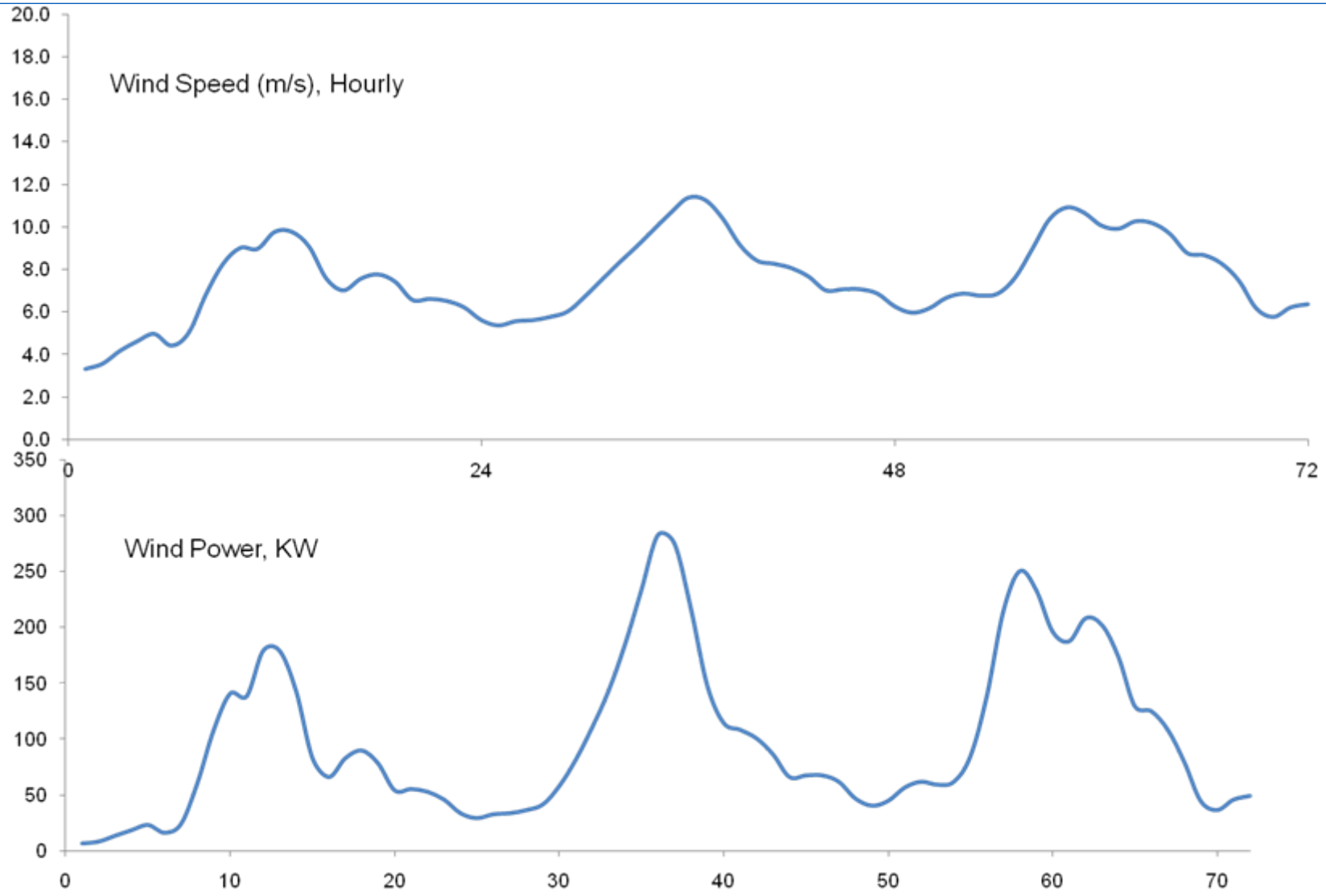
Hybrid

	Wind Speed (m/s)	Wind Power KW	Radiation	Solar Power	Power (Wind + Solar)	Load	Balance	Efficiency	300000 MWh
Jan	6.30	36023	6.5	55664	91687	82150	9537	0.88	308393
Feb	5.30	20064	6.4	51272	71336	76850	-5514	1.14	302127
Mar	5.40	22685	5.5	47101	69786	82150	-12364	1.14	288077
Apr	5.90	28634	4.2	34808	63441	79500	-16059	1.14	269828
May	7.00	49414	3.2	27404	76818	82150	-5332	1.14	263770
Jun	8.30	79717	2.80	23205	102922	79500	23422	0.88	284381
July	7.50	60778	3.20	27404	88182	82150	6032	0.88	289689
Aug	6.70	43330	3.70	31686	75015	82150	-7135	1.14	281582
Sep	6.10	31645	4.60	38123	69768	79500	-9732	1.14	270522
Oct	6.70	43330	5.40	46244	89574	82150	7424	0.88	277055
Nov	6.30	34861	5.80	48068	82929	79500	3429	0.88	280072
Dec	6.90	47327	6.20	53095	100422	82150	18272	0.88	296152
Total		497808		484073	981880	969900	11980		
CF		17%		17%					

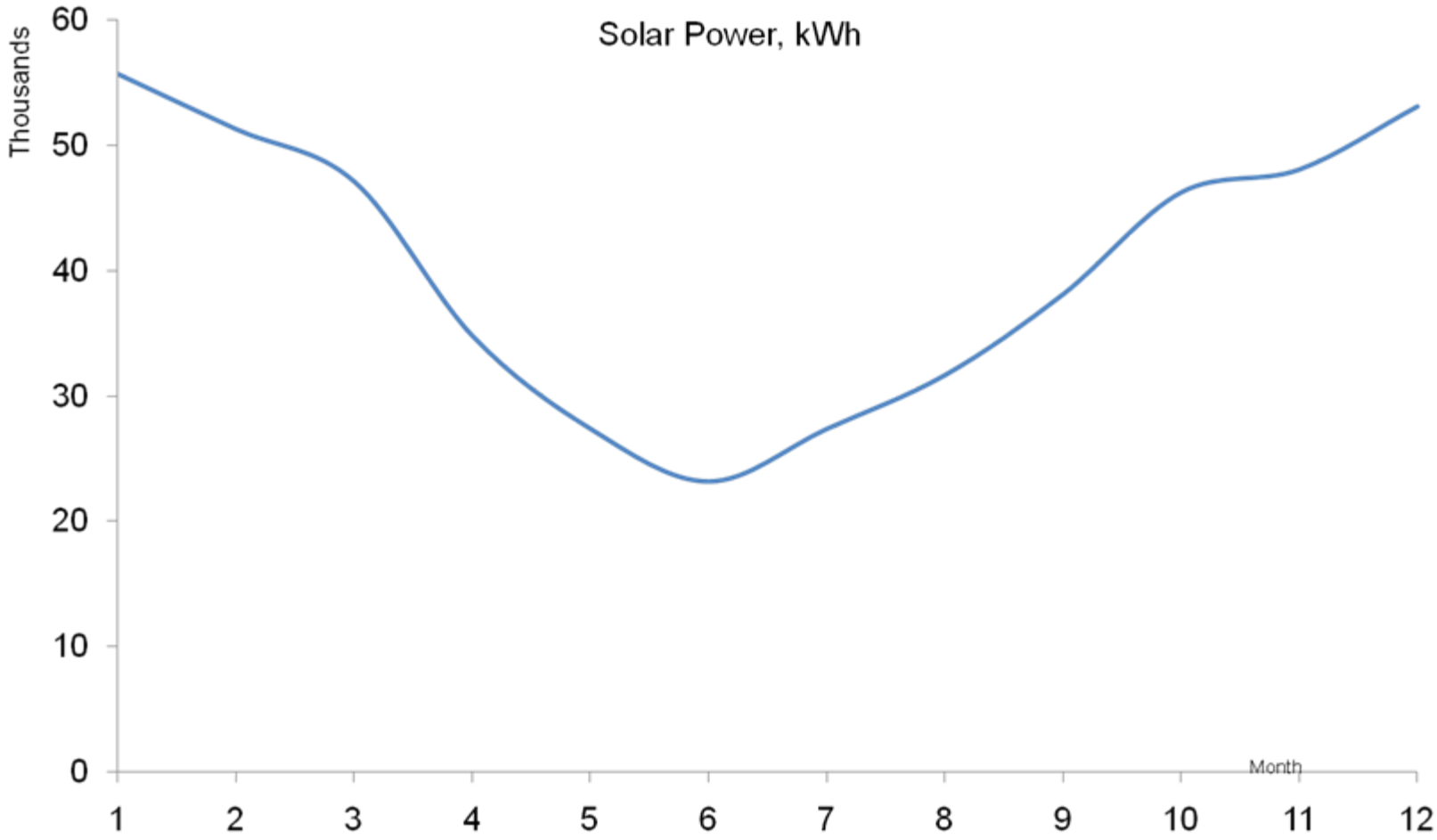
Solar energy



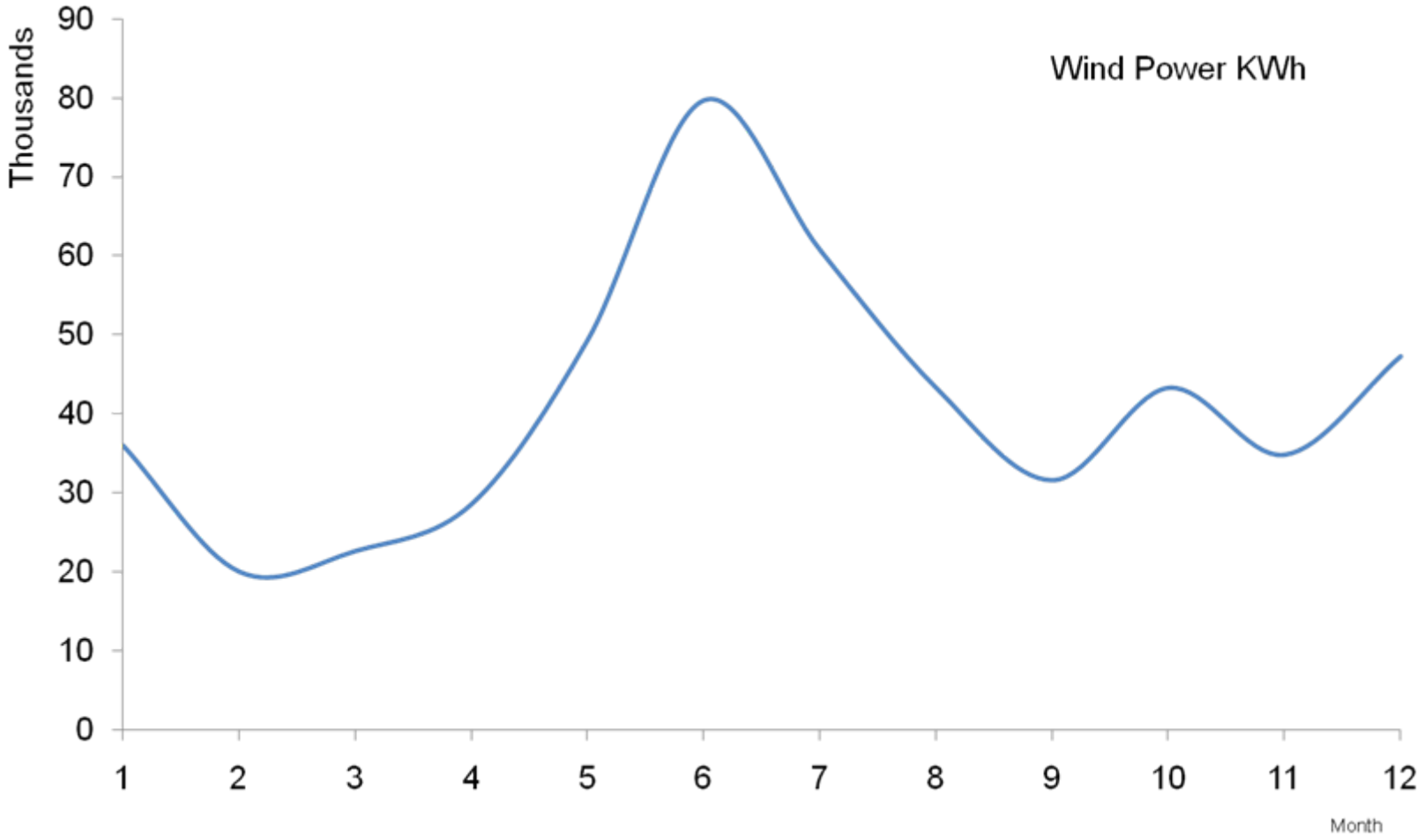
Wind power


Wind Speed (m/s), Hourly
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0
24
48
72
Wind Power, KW
350
300
250
200
150
100
50
0
0
10
20
30
40
50
60
70

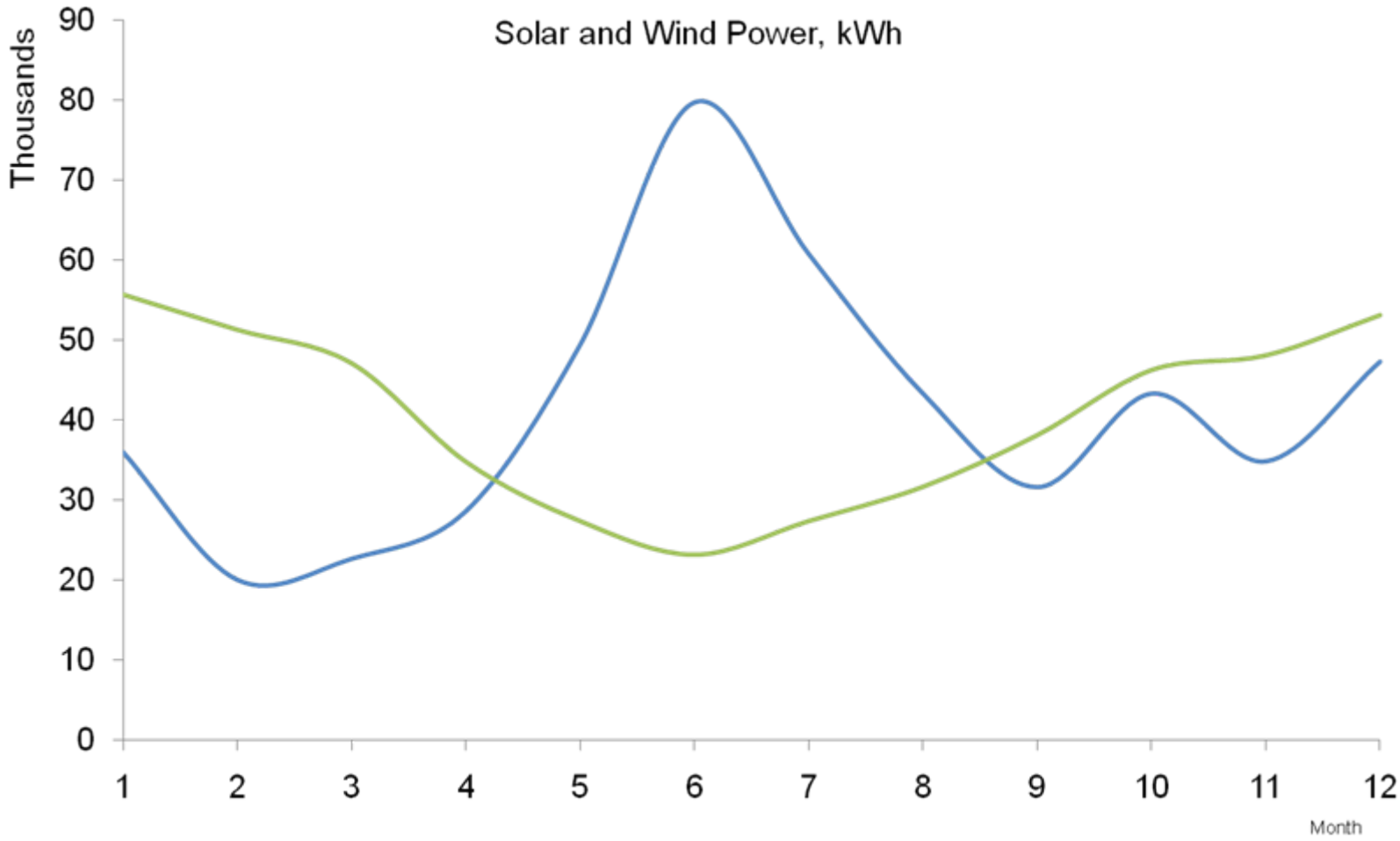
Solar energy



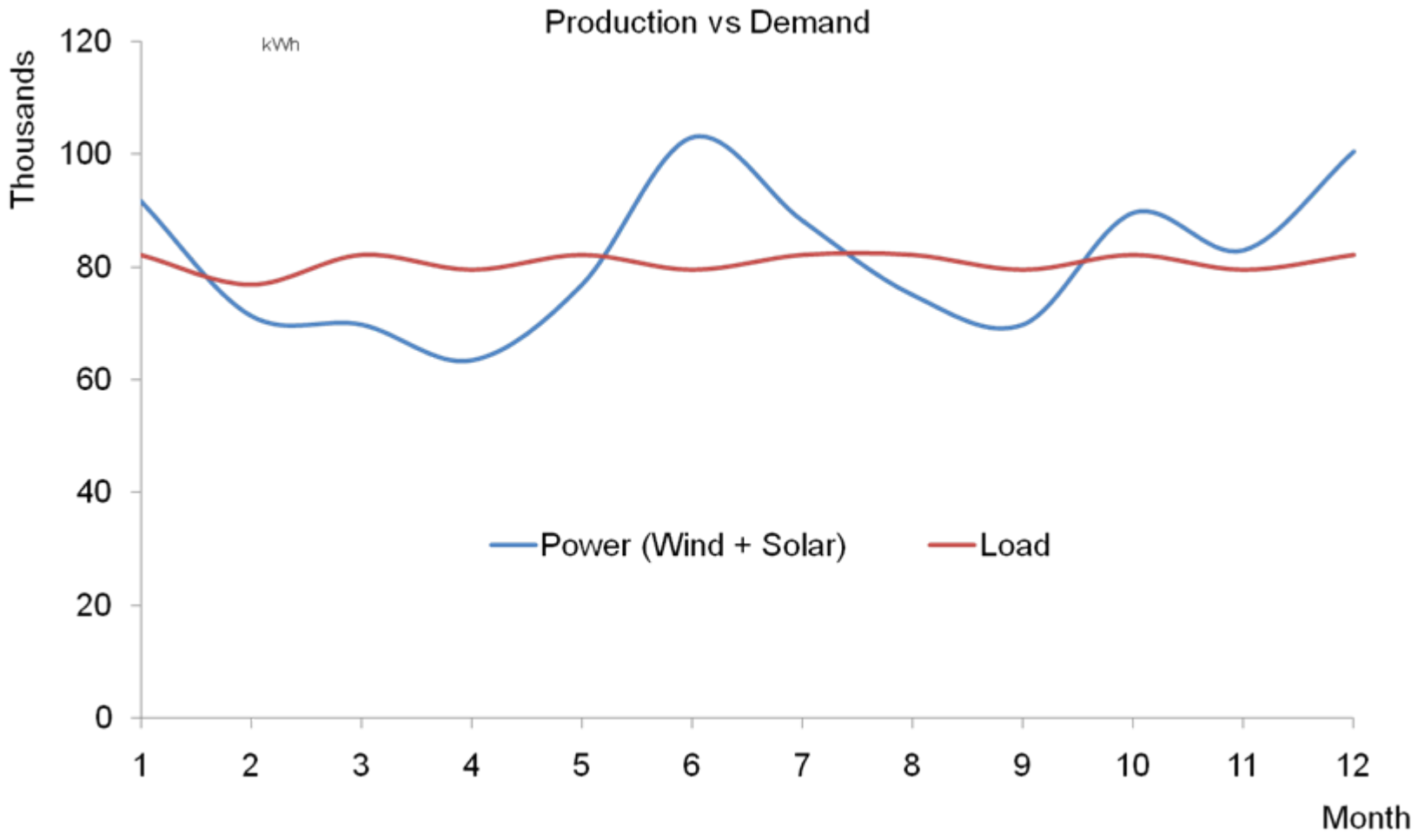
Wind power


Wind Power KWh
Thousands
90
80
70
60
50
40
30
20
10
0
1
2
3
4
5
6
7
8
9
10
11
12
Month

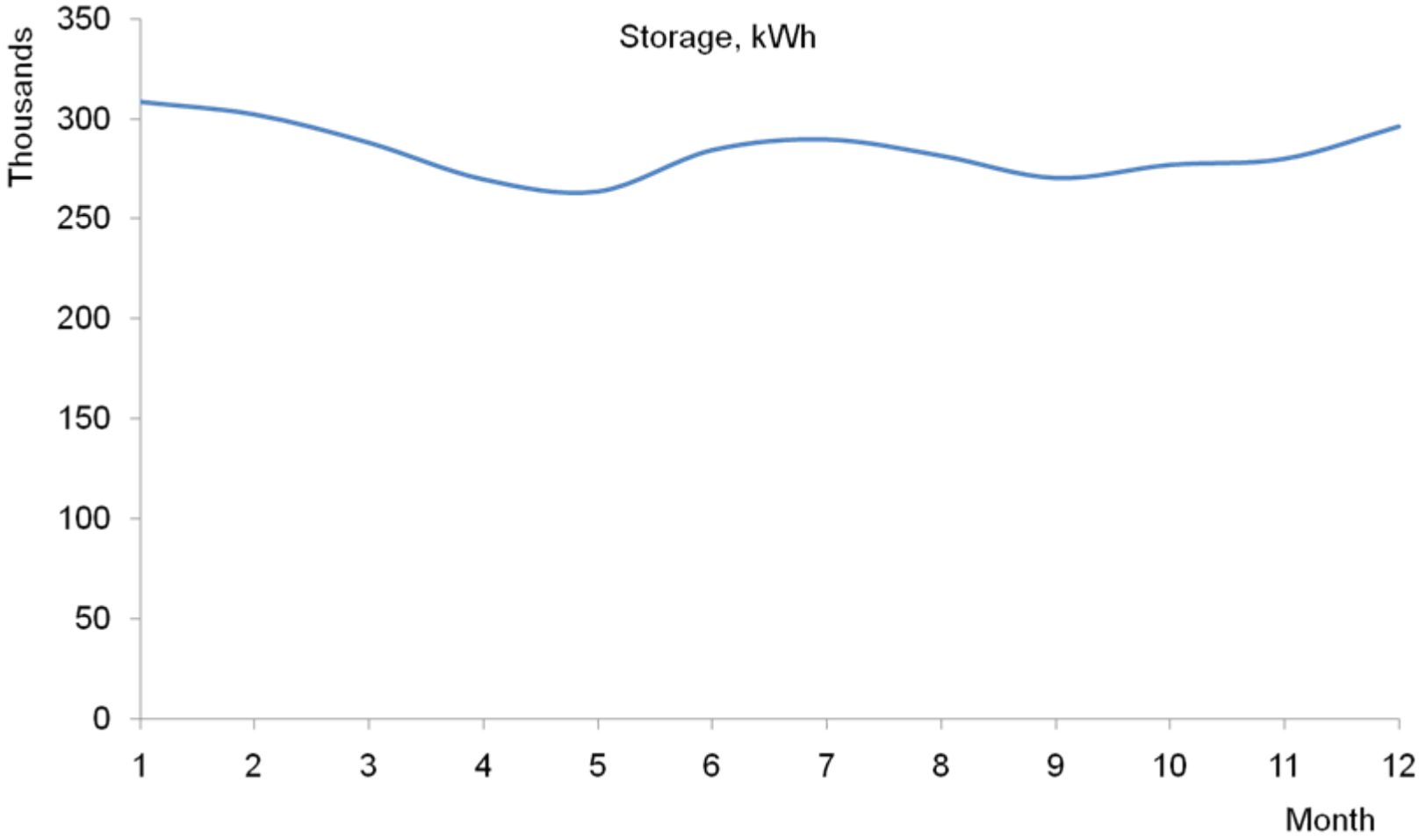
Solar energy + wind power



Supply & demand



Storage


Storage, kWh
Thousands
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
11
12
Month

Conclusions

The variable natures of power generation from intermittent sources are considered as weaknesses of natural resources solar & wind power.

Integration of an energy storage technology causes the intermittent power sources have little effect on the system's operation.

Energy storage technologies provide opportunity for the generation side to meeting the level of power quality as well as reliability required by the demand side. Energy storage can also provide emergency power and peak shaving opportunity.

Energy storage is especially important for decentralized power supply system by giving the more load-following capability, which is an important factor from generation side management.

Thank You

Sustainable energy solutions protect environment and conserve natural resources