Sustainable electric energy supply by decentralized alternative energy technologies

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Sources

1. International Energy Agency (IEA)
2. Energy Information Administration (EIA)
3. CSIRO publications
4. World Energy Outlook
5. Oil & Gas Journals
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
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

- United States: 21,757.0
- Canada: 5,200.0
- Latin America: 123,487.0
- Western Europe: 15,371.5
- Africa: 117,572.4
- Middle East & Former USSR: 743,857.5
- Asia & Pacific: 128,254.0
- Asia & Pacific: 39,016.9
Location of the World's Gas Reserves

- United States: 5,925.0
- Canada: 1,665.0
- Western Europe: 5,396.0
- Former USSR: 58,113.0
- Middle East: 72,319.0
- Africa: 14,165.0
- Latin America: 7,716.0
- Asia & Pacific: 14,824.0
Location of the World's Main Coal Reserves

- USA: 247
- Canada: 7
- Columbia: 14
- Brazil: 31
- South Africa: 49
- India: 157
- Russia: 92
- China: 115
- Australia: 79

Australian Coal Association
Location of the World's Main Uranium Reserves
World’s sun radiation kWh/m²/year

- USA: 1200 kWh/m²/year
- EU: 1000 kWh/m²/year
- Middle east: 1650 kWh/m²/year
- India: 1650 kWh/m²/year
- Rest of Asia: 1250 kWh/m²/year
- Australia: 1750 kWh/m²/year
- Latin America: 1350 kWh/m²/year
How fast are we using them?
End-use energy consumption, by Fuel Shares (IEA)
Only 11 Cents a cup
World Electricity generation by fuel (IEA)

- **1973, Total: 6116 TWh (10^{12}Wh)**
  - Coal: 38%
  - Gas: 12%
  - Nuclear: 3%
  - Hydro: 21%
  - Oil: 25%
  - Others (solar, wind..): 1%

- **2005, Total: 18235 TWh**
  - Coal: 40%
  - Gas: 20%
  - Nuclear: 15%
  - Hydro: 16%
  - Oil: 7%
  - Others (solar, wind..): 2%
Can Nuclear energy help?

Technical, Safety, social issues, hard to convince public
Nuclear power is a low-carbon source of electricity. Nuclear power can help reduce dependence on imported fuels such as oil and gas.

Unlike oil and 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?


<table>
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<tr>
<th>Technology</th>
<th>Liters/kWh</th>
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<tbody>
<tr>
<td>Nuclear</td>
<td>2.3</td>
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<tr>
<td>Coal</td>
<td>1.9</td>
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<tr>
<td>Oil</td>
<td>1.6</td>
</tr>
<tr>
<td>Combined Cycle gas</td>
<td>0.95</td>
</tr>
<tr>
<td>Wind</td>
<td>0.004</td>
</tr>
<tr>
<td>Solar</td>
<td>0.110</td>
</tr>
</tbody>
</table>
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

[Graph showing the increase in global cumulative PV capacity from 1994 to 2009.]
Solar PV

Solar PV, World Capacity in 2009: 21 GW

Germany | Spain | Japan | US | Italy | South Korea | Other EU | ROW

[Bar chart showing the world capacity in 21 GW]
Solar PV

Solar PV, World Capacity in 2009: 21 GW

- Germany
- Spain
- Japan
- US
- Italy
- South Korea
- Other EU
- ROW

Total: 9.8

Individual capacities in GW:
- Germany: 1.8
- Spain: 0.9
- Japan: 1.1
- US: 1.2
- Italy: 2.6
- South Korea: 3.4
Solar PV

Solar PV, % of the World Capacity in 2009

- Germany: 46.2%
- Spain: 16.0%
- Japan: 12.3%
- US: 5.7%
- Italy: 5.2%
- South Korea: 5.1%
- Other EU: 8.5%
- ROW: 4.2%
Wind Power
Wind power

Global Cumulative installed Wind capacity

MW
Wind power

Wind Power, World Capacity in 2009: 159 GW
Wind power

Wind Power, World Capacity in 2009: 159 GW

- US
- China
- Germany
- Spain
- India
- Italy
- France
- UK
- Portugal
- Denmark
- ROW
Hybrid

Solar PV Energy

DC/DC

AC/DC

Energy Storage Unit

Charge Controller

DC/AC

Wind Power

DC

AC
<table>
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<tr>
<th># of WT</th>
<th>Rated WT</th>
<th>Eff. WT</th>
<th>Air Density</th>
<th>Radius, m</th>
<th>WS, m/s</th>
<th>Old H</th>
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<td>330</td>
<td>0.45</td>
<td>1.05</td>
<td>10</td>
<td>6.25</td>
<td>10</td>
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<tr>
<td>New H</td>
<td>Roughness</td>
<td>De-Rating</td>
<td>PV-kW</td>
<td>Load/day</td>
<td>Efficiency</td>
<td>Storage</td>
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<tr>
<td>20</td>
<td>0.15</td>
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<td>325</td>
<td>2650</td>
<td>0.85</td>
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### Hybrid

<table>
<thead>
<tr>
<th>Month</th>
<th>Wind Speed (m/s)</th>
<th>Wind Power KW</th>
<th>Radiation</th>
<th>Solar Power</th>
<th>Power (Wind + Solar)</th>
<th>Load</th>
<th>Balance</th>
<th>Efficiency</th>
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<tr>
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<td>36023</td>
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<td>0.88</td>
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<td>22685</td>
<td>5.5</td>
<td>47101</td>
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<td>3.2</td>
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<td>Oct</td>
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<td>18272</td>
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<td>Total</td>
<td></td>
<td>497808</td>
<td></td>
<td>484073</td>
<td>981880</td>
<td>969900</td>
<td>11980</td>
<td></td>
<td></td>
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<td>CF</td>
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<td></td>
<td></td>
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<td>17%</td>
<td>17%</td>
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</tr>
</tbody>
</table>
Solar energy
Wind power
Solar energy

Solar Power, kWh

Thousands

Month
Wind power

Graph: Wind Power KWh

Y-axis: Thousands

X-axis: Month

The graph shows the monthly variations of wind power in KWh.
Solar energy + wind power

Solar and Wind Power, kWh

Month

Thousands
Supply & demand

Production vs Demand

Thousands

Month

Power (Wind + Solar)  Load

kWh
Storage

Storage, kWh

Month

Thousands

0 1 2 3 4 5 6 7 8 9 10 11 12
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