The Viability of Nuclear Power in South Africa

Andrew Kenny
Independent Energy Commentator
arkenny40@absamail.co.za
A Personal Note

• If you were expecting Brian Dames, the CEO of Eskom, apologies. I’m the anti-climax.

• My qualifications: Degrees in Physics & Engineering. 17 years in industry, in SA and the UK, including Eskom, coal and nuclear.

• I am an environmentalist, and this is my fundamental philosophy:
  – We have only got one planet, and we must love her and everything that lives on her, and do everything we can to protect her.
  – We must always act in such a way as to cause the most benefit and the least costs to people and the environment.
  – Our choices must be made on rational and scientific grounds, based on evidence, NOT on ideology or superstition.
  – We Must work WITH nature not AGAINST her.

• With this philosophy, I have no choice but to support nuclear power.
Why South Africa Needs Nuclear Power

- South Africa is desperately short of electricity generation.
- For the economy to develop and grow, we must beneficiate our raw materials, add value to them and increase our manufacturing industry. This needs a lot of electricity.
- The new coal stations, Medupi & Kusile, will help but will not nearly be enough.
- We need much more power, and we need it at the coasts and in the west and south of the country.
- We need electricity that is safe, clean, economic, sustainable and reliable.
- Nuclear power is the best option by far.
Types of Electricity Supply We Need

• **Small scale off the electricity grid:** houses, schools, clinics, farms.
  – Solar & wind are excellent
  – Nuclear is useless (except on Mars)

• **Peaking electricity.** Producing large amounts of electricity for short periods at short notice
  – Gas turbines & pumped storage are excellent
  – Nuclear is useless.

• **Baseload electricity.** 24 / 365. Large, constant, reliable supply.
  – Solar & wind are useless.
  – Gas might be good **IF** the price of gas is right.
  – Hydro can be good **IF** you have the right rivers and the right sites, which we don’t.
  – Coal is very good **IF** you have the right coalfields.
  – Nuclear is excellent.

• I am only referring to nuclear for baseload power.
Why is Nuclear the Best Energy Source: Safest & Cleanest?

• Because of nature (not man).
• The nuclear force is by far the strongest force in nature.
• This means that a very small amount of material can provide a very large amount of energy very reliably.
• This means minimum disruption to the environment.
• This means that it can be easiest controlled, making it the safest.
• It is essential that all energy technologies should be compared over the full energy cycle, which includes extraction and processing of fuel, manufacture, construction, operation, waste disposal & decommissioning.
Comparison of Nuclear Accident Risks with Those from Other Energy Sources.

Number of Accidents with at least 5 Deaths in Full Energy Chain 1969 to 2000

Coal: 1119
Oil: 397
Natural gas: 135
LPG: 105
Hydropower: 11
Nuclear: 1

Total Deaths in nuclear and wind power to end of 2010

Benjamin K. Sovacool. A Critical Evaluation of Nuclear Power and Renewable Electricity in Asia

Deaths / PWh for Wind & Nuclear from their Inception to 2011

PWh from Electricity Outlook 2010, EIA

Wind: 52.11
Nuclear: 1.13
A Spectacular Demonstration of Nuclear Safety

Fukushima

World’s Second Worst Nuclear Power Accident

4 Nuclear Power Units Damaged
On 11 March 2011, the largest earthquake & tsunami on record struck Japan from her north east coast

20,000 people killed by earthquake & tsunami
Fukushima: dramatic vindication of nuclear safety

- The worst tsunami on record struck 6 old fashioned BWRs, designed in the 1960s, run by a corrupt & negligent company, TEPCO.
- All running units shut down safely but tsunami removed power for the cooling pumps.
- Severe damage in 4 plants.
- Large numbers of people evacuated, huge disruption.
- Number of people killed by the radiation so far: 0
- Number of people likely to be killed by the radiation in future: 0
- **What more can your ask for? What better demonstration of nuclear safety?**
- Another nuclear power “disaster” that kills nobody (like Three Mile Island in the US in 1979).
- Japanese geologists have shown there were worse tsunamis in the last thousand years. The plants should have been designed against them, which is very easy to do.
- Modern reactor designs, such as the Westinghouse AP1000, would have had few problems with the Fukushima conditions.
- PBMR or TH-100 would have had none.
Radiation: Fukushima accident compared with natural levels

- Background, Cape Town
- Background, Paarl
- Max to Koeberg radiation worker
- Background levels at Ramsar, Iran
- Average dose at Fuku in affected Zone
- Highest dose to civilian at Fuku
The Fukushima Daiichi Event: World Earthquake Distribution

Note the enormous earthquake activity near Japan

Fukushima Daiichi designed against a 5.7 metre tsunami!

Koeberg designed against a 7 metre tsunami!

Note the feeble earthquake activity near South Africa
The decision by Germany & Japan to phase out nuclear power because of Fukushima is completely MAD.

All alternative forms of energy will be more expensive and more dangerous. (Nuclear was the cheapest source of electricity in both countries.)

The price of electricity is already going up in both countries.

Poor people are suffering under rising electricity bills.

Electricity is becoming unreliable in Germany because of rising renewable energy (mainly wind), which puts strain on the grid.

Germany is now building about 17 new coal stations. A 2,200 MW coal station was opened in August 2012 at Cologne by Chancellor Angela Merkel. So much for greenhouse emissions!

Japan has now got a trade deficit because of the very high price of increased gas imports.
Sustainability

• Nuclear fuels, uranium & thorium, are massively abundant in the ground & the sea
  – Because of nature, their energy is highly concentrated & very reliable

• Because of the low price of uranium, the mining houses have hardly scratched the surface in looking for it
  – In 2005 “Inferred”, “Prognosticated” & “Speculative” uranium reserves were 14,798 thousand tons: 218 years at 2005 consumption. (World Energy Outlook 2006. NEA/IAEA)

• Breeder reactors effectively multiply the uranium reserves 50x.

• Thorium, 4x as abundant as uranium, has even better prospects.
  – TH-100 (Thorium-100 Reactor being developed by Steenkampskraal Thorium Ltd)

• Nuclear fuel will also last the life of the planet.

• Raw nuclear raw fuel is a fairly small part of the costs of nuclear power. If it were free, it wouldn’t make too much difference.
Economics

- Nuclear power is everywhere economic and often, such as in France and Germany, the cheapest source of electricity.
- Nuclear power usually has higher capital costs than coal, and certainly higher than gas, but it has low production costs (fuel, maintenance and operation).
- Nuclear power stations have high load factors (capacity factors) and long lives (a modern station has a life of 60 years) and so their levelised cost of electricity (cost per kWh over the lifetime of the station) is very low.
- High capital costs in the past have been caused mainly by one off designs and by delays (from regulation and construction). A building programme with many units of the same design will bring costs down dramatically. So will more efficient and better prepared regulation.
- In Europe and the US, new nuclear capital costs are estimated to be about $3 to $7 / watt. In China they are about $2 to $3 / watt. This is cheaper than many new coal stations, including Medupi and Kusile.
US Electricity Production Costs (cents/kWh)

Source: Ventyx Velocity Suite
Important note: This is NOT comparing like with like. Eskom gives you electricity when you want it for as long as you want it. The customer is king. With wind & solar, you are compelled to buy the electricity whenever the generator is able to produce it, which is seldom. The producer is king.
Nuclear Power & Global Warming

• The official view of NIASA is that rising CO2 presents a danger to the planet’s climate and we must try to reduce it.
• I personally disagree. I do not believe that rising CO2 is changing the climate in a dangerous way.
• However, if you do want to reduce CO$_2$ emissions, nuclear power is by far the best technology.
• This is over the full energy cycle, including mining, fuel processing, construction, operations and decommissioning.
• For fuel enrichment, nuclear can provide its own energy for the electricity supply (unlike wind and solar).
• Nuclear power displaces generation from fossil fuels
• Wind power does NOT displace generation from fossil fuels
  – The wind ramping up and down requires coal or gas stations to run less efficiently, using more coal/kWh
Greenhouse emissions for Full Energy Chain of different Generation Technologies


The diagram shows the greenhouse emissions for various energy sources expressed in gCeq per kWh. The emissions range from 0 to 700 gCeq per kWh. The energy sources are categorized as follows:

- Nuclear
- Wind
- Biomass
- Hydro
- Solar PV
- Nat gas
- Oil
- Coal
- Lignite
Siting

• Coal.
  – An average big Eskom coal station burns 15 million tons/a year (1,700 tons/hour)
  – It is too expensive to transport this amount any distance, so you must build the coal station next to a coalfield
  – All the big coalfields are in the north east of the country
• Hydro.
  – Must be built on a suitable site on a river. (We have no such sites left.)
• Gas.
  – Need pipelines from the gas fields to the power station.
• Nuclear.
  – Because the fuel is so tiny and lasts such a long time, you can site the nuclear station wherever to you
    • Close to centres of demand (especially at the coast for SA)
    • Close to good cooling (incl. the sea)
## Energy Out / Energy In for Various Energy Sources

<table>
<thead>
<tr>
<th>Generation Technology</th>
<th>Type</th>
<th>Energy in as % of lifetime output</th>
<th>Energy ratio (output/input)</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydro</td>
<td></td>
<td>2</td>
<td>50</td>
<td>Uchiyama 1996</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.3</td>
<td>43</td>
<td>Held et al 1977</td>
</tr>
<tr>
<td>Nuclear (centrifuge</td>
<td>PWR/BWR</td>
<td>1.7</td>
<td>59</td>
<td>ERDA 76/1, Appendix B</td>
</tr>
<tr>
<td>enrichment)</td>
<td>PWR/BWR</td>
<td>1.3</td>
<td>76</td>
<td>Kivisto 2000</td>
</tr>
<tr>
<td></td>
<td>PWR</td>
<td>2.2</td>
<td>46</td>
<td>Uchiyama 1996</td>
</tr>
<tr>
<td></td>
<td>BWR</td>
<td>2.3</td>
<td>43</td>
<td>Inst. Policy Science 1977</td>
</tr>
<tr>
<td></td>
<td>BWR</td>
<td>2.1</td>
<td>47</td>
<td>Inst. Policy Science 1978</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.8</td>
<td>20.8</td>
<td>ERDA 76/1, Appendix B</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>20.0</td>
<td>Held et al 1977</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5.8</td>
<td>17.2</td>
<td>Kivisto 2000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.2</td>
<td>23.8</td>
<td>Uchiyama 1996</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6.5</td>
<td>15.4</td>
<td>Oak Ridge Assoc.Univ.1976</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6.1</td>
<td>16.4</td>
<td>Oak Ridge Assoc.Univ.1977</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9.5</td>
<td>10.5</td>
<td>Uchiyama et al 1991</td>
</tr>
<tr>
<td>Coal</td>
<td></td>
<td>3.5</td>
<td>28.6</td>
<td>Uchiyama et al 1992</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5.9</td>
<td>16.9</td>
<td>Uchiyama 1996</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6</td>
<td>16.8</td>
<td>Uchiyama et al 1991</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7</td>
<td>14.2</td>
<td>Inst.Policy Science 1977</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>Pipe</td>
<td>3.8</td>
<td>26.3</td>
<td>Kivisto 2000</td>
</tr>
<tr>
<td></td>
<td>LNG</td>
<td>17.9</td>
<td>5.6</td>
<td>Uchiyama et al 1991</td>
</tr>
<tr>
<td></td>
<td>LNG</td>
<td>16.7</td>
<td>6.0</td>
<td>Uchiyama 1996</td>
</tr>
<tr>
<td>Solar</td>
<td>PV rooftop</td>
<td>9.4</td>
<td>10.6</td>
<td>Held et al 1997</td>
</tr>
<tr>
<td></td>
<td>PV utility</td>
<td>11.1</td>
<td>9.0</td>
<td>Uchiyama 1996</td>
</tr>
<tr>
<td></td>
<td>amorph.sil.</td>
<td>20</td>
<td>5.0</td>
<td>Uchiyama 1996</td>
</tr>
<tr>
<td></td>
<td></td>
<td>27</td>
<td>3.7</td>
<td>Kivisto 2000</td>
</tr>
<tr>
<td>Wind</td>
<td></td>
<td>8.3</td>
<td>12.0</td>
<td>Resource Research Inst.1983</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16.7</td>
<td>6.0</td>
<td>Uchiyama 1996</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.9</td>
<td>34.5</td>
<td>Kivisto 2000</td>
</tr>
</tbody>
</table>
Waste

• Waste is the worst of all the misconceptions over nuclear power.
• Every single energy technology, without exception, including wind & solar, produces “deadly” waste that remains dangerous for billions of years (or forever).
• Everything on Earth is made of atoms, with nuclei at their centres.
• Some of the nuclei are stable
  – Which means they last forever, until the end of time
• Some of the nuclei are unstable
  – Which means they do not last forever
  – They break up, releasing radiation
  – They are radioactive
Some Wastes from other Energy Sources

• Coal:
  – Mercury, arsenic, cadmium etc
  – All “deadly” and lasting forever
  – Blown into the air we breathe or dumped onto ashtips

• Solar:
  – Lead, cadmium, arsenic
  – All “deadly” and lasting forever

• Wind:
  – Heavy metal toxins
  – “Deadly” and lasting forever
  – Radioactive thorium: half-life 14 billions years
What to do with waste

• You can only do two things:
  – 1. Use the materials again (recycle them)
  – 2. Don’t use them again (store them).

• So to advocates of solar power, which uses “deadly” lead, cadmium & arsenic in its power units:
  • 1. Where is your final repository for storing this waste for billions of years - with a guarantee that harmful amounts never leak out?
  • 2. Where is your plan for recycling this waste for billions of years - with a guarantee that harmful amounts never escape into the environment?

• They have no repository and no recycling plan. They haven’t a clue where these toxins will be in a hundred years time, let alone a billion.

• Does this threaten future generations?

• Of course not! We know perfectly well how to handle and store dangerous materials from year to year, from decade to decade.

• But we know even better how to handle nuclear waste, which is small, solid and stable, and we’ve been doing so for 50 years with complete success.

• There is nothing in high level nuclear waste (spent fuel) that you don’t find in nature, including:
  – Plutonium: formed when a naturally occurring neutron is captured by naturally occurring Uranium-238.
  – Fission products: formed by spontaneous fission of naturally occurring uranium

• After about 500 years, high level nuclear waste is less radioactive than the original uranium ore.
Nuclear Fuel: Spent Fuel (High Level Waste) Looks Just the Same

Typical Nuclear Fuel Pellet
(uranium oxide)

Typical Nuclear Fuel Assembly
(about 3.7 metres long)
IRP2010: South Africa Generation Capacity Planned in 2030

Total, 2010

Total, 2030

New, 2030

Coal

Nuclear

CCGT

Hydro

Pumped Storage

CSP

PV

Other
AP1000 being built at Sanmen, China. Two Units. First will come on stream in 2013 (Next year)

<table>
<thead>
<tr>
<th>Worldwide</th>
<th>Number</th>
<th>Capacity (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reactors under construction</td>
<td>64</td>
<td>64 175</td>
</tr>
<tr>
<td>Reactors Planned</td>
<td>160</td>
<td>177 915</td>
</tr>
<tr>
<td>Reactors Proposed</td>
<td>323</td>
<td>366 415</td>
</tr>
</tbody>
</table>

Nuclear compared with Wind

• “Renewable” energy is now the prevailing ideology among the chattering classes (most of whom have no engineering knowledge).
• There is great political pressure to go for renewable energy for grid electricity.
• This would be calamitous: bad for the environment, bad for the economy, bad for electricity supply and terrible for the poor.
• To see why, here is a comparison between nuclear power and the world’s most popular renewable power, wind power.
• Let’s compare our only nuclear power station, Koeberg, with our biggest wind farm, Darling.
Darling Wind Farm
4 x 1.3 MW
Completed 2008

Koeberg Nuclear Power Station
2 x 1,800 MW
Completed 1985
### Koeberg Nuclear Station and Darling Wind Farm

**Sources:** Eskom & [www.darlingwindfarm.co.za](http://www.darlingwindfarm.co.za)

<table>
<thead>
<tr>
<th></th>
<th>Koeberg</th>
<th>Darling Wind Farm</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Capacity (MW)</strong></td>
<td>1,800 (2x 900)</td>
<td>5.2 (4x 1.3)</td>
</tr>
<tr>
<td><strong>Production (GWh/y)</strong></td>
<td>12,600</td>
<td>8.6</td>
</tr>
<tr>
<td><strong>Capacity Factor</strong></td>
<td>80%</td>
<td>18.9%</td>
</tr>
<tr>
<td><strong>Completion</strong></td>
<td>1985</td>
<td>2008</td>
</tr>
<tr>
<td><strong>Construction time</strong></td>
<td>9 years</td>
<td>8 months</td>
</tr>
<tr>
<td>(exc. planning, contracting, EIA etc)</td>
<td>9 years (including sabotage)</td>
<td>8 months</td>
</tr>
</tbody>
</table>

- Number of Darling Wind turbines needed to produce the same amount of electricity as Koeberg
  
  \[ \frac{12,600}{8.6 \times 4} = 5,860 \text{ wind turbines}. \]

- Time needed to build these 5,860 wind turbines if you built them at the same rate as Darling was built
  
  \[ \frac{5,860}{4 \times 0.667} = 970 \text{ years} \]

- Rate of building needed to build these 5,860 wind turbines if you built them in the same time as it took to build Koeberg
  
  \[ \frac{5,860}{9} = 651 \text{ turbines / year} = 12.5 \text{ turbines / week for 9 years}. \]
Koeberg & Darling (continued)

• 5,860 wind turbines would require thousands of kilometres of transmission lines and service roads.
• They would produce the same amount of electricity as Koeberg but could not possibly replace it.
• Koeberg produces electricity reliably and predictably, when you want it, for as long as you want it.
• The wind turbines produce power unreliable and unpredictably, with violent fluctuations in output.
• Those 5,860 wind turbines would be useless without a 100% back-up with an alternative energy supply:
  – Gas turbines? (Extremely expensive)
Use of Natural Resources

Because wind & solar energy are so dilute & intermittent you need very large structures to collect very small amounts of energy (the exact opposite of nuclear power)

Solar & wind require far more resources per kWh of electricity generated than nuclear, with correspondingly greater damage to the environment.
Steel & Concrete Requirements for Nuclear & Wind Plants

Metal And Concrete Inputs For Several Nuclear Power Plants Per F. Peterson, Haihua Zhao, and Robert Petroski University of California, Berkeley, 4153 Etcheverry Berkeley, California 94720-1730 peterso

The chart shows the steel and concrete requirements for nuclear and wind plants. The units are cubic meters per average megawatt (M³/Av MW).

- **Nuclear**: Small requirements for steel and concrete.
- **Wind**: High requirements for steel and very high for concrete.

The chart clearly indicates that wind plants have significantly higher concrete requirements compared to nuclear plants, which have lower requirements for both steel and concrete.
### Time to build Nuclear & Wind Plants

<table>
<thead>
<tr>
<th>Station</th>
<th>MW</th>
<th>Completed</th>
<th>Years To Build</th>
<th>Wind Equivalent MW</th>
<th>Number of Turbines (Darling type)</th>
<th>Turbines/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Koeberg</td>
<td>1800</td>
<td>1985</td>
<td>9</td>
<td>6,300</td>
<td>4,846</td>
<td>538</td>
</tr>
<tr>
<td>Tomari-3, Japan</td>
<td>920</td>
<td>2009</td>
<td>5</td>
<td>3,220</td>
<td>2,477</td>
<td>495</td>
</tr>
<tr>
<td>AP1000, China</td>
<td>1100</td>
<td>2013</td>
<td>5</td>
<td>3,850</td>
<td>2,961</td>
<td>592</td>
</tr>
<tr>
<td>EPR, Finland</td>
<td>1600</td>
<td>2014?</td>
<td>10?</td>
<td>5,600</td>
<td>4,308</td>
<td>431</td>
</tr>
</tbody>
</table>

Assumption: load factor of nuclear 3.5x that of wind (generous to wind)

Competing with the slowest nuclear construction, you would have to build more than one wind turbine / day

IRP2010 plans for 9,600 MW of nuclear by 2030. This is tight but can be done. Say 3,200 MW on each of the three sites.

Typically it takes eight years from placing orders to completing a two unit nuclear station.
Deadly Waste Kills Local People
Terrible Environmental Dangers of a Source of Energy Production

Communities devastated by long lived toxins of this energy source.

Official studies carried out five years ago in Dalahai village in China confirmed there were unusually high rates of cancer along with high rates of osteoporosis and skin and respiratory diseases.

Toxic wastes: including, least of all problems, radioactive waste, thorium. With a half-life of 14,000,000,000 * years. Chemical wastes incomparably worse, including heavy metals that last forever. Infant abnormalities. Fish dying in rivers.

What is the energy source causing this terrible harm to mankind and the environment?

Wind power. These Chinese communities are suffering and dying to produce neodymium, a rare earth used in wind turbine generators.

NB. This is history now. Rare Earth mining in China has been cleaned up. Because thorium has such a long half-life, its radiation is very feeble.
Nuclear Generation Production: UK: 9 Jun to 8 Sep 2011.
Source: NETA
Total Nuclear Capacity: 10,137 MW
Wind Generation Production.  UK.  9 Jun to 8 Sep 2011.
Source: NETA
Total Wind Capacity:  5,000 MW +

Questions:

1. When the wind (yellow) is not working, what energy (green) provides the power?

2. Who pays the **huge** costs from the violent fluctuations of wind power?
   (i) Dangerous strains on the national grid
   (ii) Wasteful, inefficient, damaging production from back-up provider?
Characteristics of Wind Turbines for Grid Electricity

Gigantic is Beautiful!
This should be the motto of wind power

Massive, Wasteful, Inefficient use of the Earth’s Resources

Totally dependent on Governments to Enforce
Huge Operating Subsidies

Hopelessly Unreliable, Pitifully Low Capacity Factors

Suffering to Local People: Drop in Property Values,
Illness from Wind Turbine Syndrome

Taking over: Europe's biggest onshore wind farm is Whitelee, on the outskirts of Glasgow
Bird & Bat Deaths from Wind Turbines

California Energy Commission found that a single wind farm, Altamont Pass, killed 4,700 birds a year, including 1,300 protected raptors, including 100 golden eagles.

Short-toed Eagle killed by wind turbine, Spain
White Tailed Sea Eagle killed by wind turbine, Norway

Excuse from wind industry:
“Oh, but cats kill more birds than wind turbines”

How many eagles are killed by cats?
Now look at Koeberg. Surrounded by a beautiful coastal fynbos nature reserve. Safe home to endangered birds, including the Black Oyster Catcher.

For the sake of our economy and our Environment, let’s turn to nuclear power
Thank You
Under certain circumstances every element in the periodic table can be deadly, and most of them have isotopes that last forever - not millions of years but forever.
It’s an ill wind ....  
(from Des Muller, Group Five)
Load Factors (Capacity Factors) for Wind & Nuclear in Selected Countries


<table>
<thead>
<tr>
<th></th>
<th>Wind</th>
<th>Nuclear</th>
</tr>
</thead>
<tbody>
<tr>
<td>Denmark</td>
<td>23.0</td>
<td>-</td>
</tr>
<tr>
<td>France</td>
<td>20.4</td>
<td>77.7</td>
</tr>
<tr>
<td>Germany</td>
<td>17.0</td>
<td>83.3</td>
</tr>
<tr>
<td>Portugal</td>
<td>22.7</td>
<td>-</td>
</tr>
<tr>
<td>Spain</td>
<td>23.3</td>
<td>84.2</td>
</tr>
<tr>
<td>Sweden</td>
<td>20.3</td>
<td>77.3</td>
</tr>
<tr>
<td>UK</td>
<td>24.0</td>
<td>75.2</td>
</tr>
<tr>
<td>USA</td>
<td>24.1</td>
<td>93.2</td>
</tr>
</tbody>
</table>

Much of the loss of load factor for nuclear comes from planned shutdowns for maintenance & refuelling. It is predictable.
Fallacies & False Hope for Wind

• **Fallacies:**
  – 1. The wind is always blowing somewhere
  – 2. Periods of widespread low wind are infrequent.
  – 3. The probability of very low wind output coinciding with peak electricity demand is slight.

• The Muir Report, measured wind power production in Britain from Nov 2008 to Dec 2010 (A Report by Stuart Young, supported by the John Muir Trust), found them all wrong.

• Britain has over 3,000 wind turbines with a total capacity of over 5,000 MW.

• The report found:
  – 1. Over 124 occasions in this time when total production was less than 20 MW. No significant wind anywhere.
  – 2. At each of the four highest peak demands of 2010 wind output was respectively 4.72%, 5.51%, 2.59% and 2.51% of capacity at peak demand.

• **False Hope:**
  – The “smart grid” (highly centralised) is being held up as a magic wand that will somehow generate electricity out of nothing to make up for wind failures.
  – Actually the smart grid can do nothing but direct electricity from generator to consumer. It cannot itself generate a watt of electricity. So when the wind fails, some other generator must provide electricity.
Predictions for Wind & Solar

- In 1976, the US Dept of Energy estimated that wind power would provide about **20%** of US energy needs by **1995**.
  - The actual figure in **2006**, (30 years after this prediction) was **0.6%**.
- In 1985, an executive of the American Wind Energy Association told Congress that wind power would be "the lowest-cost source of electricity, along with hydro, available to utility by **1990**.
  - Today, **2012**, 27 years after this prediction, wind remains **far more expensive than coal, gas and nuclear**, and is only viable with huge operating subsidies.
- In 1987, Scott Sklar, executive director of Solar Industries Association, told the US Congress that solar power would provide between **10 and 20 percent of US energy needs by 2000** “quite easily”.
  - The actual figure in **2000** was **0.05%** - (200x smaller).
- (cf Silly remark about nuclear power being “too cheap to meter” made in 1954)
- Wind power is mature technology, which has been developed for at least four decades (or centuries if you consider all the applications of wind power). It has failed utterly to develop into an economic and reliable competitor with nuclear, coal, gas, hydro etc. It will fail in future. This is because of nature.
- SA does have very good conditions for solar power in the north west but solar for grid power around the world has proved to be even more expensive than wind and with even worse load factors. Again this is because of nature.

"According to the Committee's scientific assessments, there have been about 1,800 cases of thyroid cancer in children who were exposed at the time of the accident, and if the current trend continues, there may be more cases during the next decades. Apart from this increase, there is no evidence of a major public health impact attributable to radiation exposure 14 years after the accident. There is no scientific evidence of increases in overall cancer incidence or mortality in non-malignant disorders that could be related to radiation exposure. The risk of leukaemia, one of the main concerns owing to its short latency time, does not appear to be elevated, not even among the recovery operation workers. Although those most high exposed individuals are at an increased risk of radiation-associated effects, the great majority of the population are not likely to experience serious health consequences from radiation from the Chernobyl accident".

The 2005 Chernobyl Forum.

600-page report and incorporating the work of hundreds of scientists, economists and health experts, assesses the 20-year impact of the largest nuclear accident in history. The Forum is made up of 8 UN specialized agencies, including the International Atomic Energy Agency (IAEA), World Health Organization (WHO), United Nations Development Programme (UNDP), Food and Agriculture Organization (FAO), United Nations Environment Programme (UNEP), United Nations Office for the Coordination of Humanitarian Affairs (UN-OCHA), United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), and the World Bank, as well as the governments of Belarus, the Russian Federation and Ukraine.

Overall just over 50 people were killed or have subsequently died, including the 9 children from thyroid cancer - which could have been avoided

"apart from this [thyroid cancer] increase, there is no evidence of a major public health impact attributable to radiation exposure 14 years after the accident. There is no scientific evidence of increases in overall cancer incidence or mortality or in non-malignant disorders that could be related to radiation exposure." As yet there is little evidence of any increase in leukaemia, even among clean-up workers where it might be most expected. However, these workers remain at increased risk of cancer in the long term.
Exaggerations & Distortion on Chernobyl

“The two-headed animals reported in some newspapers, from what one can gather, come from the farm areas - the collective farms - and they are almost certainly due to over-fertilisation. If you just put nitrates down without measuring, it’s easy to put down 30 times too much, and have these animals getting 30 times too much. Then you start getting those genetic effects.”

-Professor Richard Wilson Mallinckrodt, Professor of Physics, Harvard University, 21st Century Science and Technology, Summer 1993

“The claim that one million severely deformed children are the result of exposure to Chernobyl radiation is not credible, and is damaging to public health in itself. Without in any way minimising the health effects of exposure to radiation, little good and much harm results from exaggerating them. Already the psycho-social effects of the accident are diminishing the quality of life and well being of millions of people. Over 2000 children are born in Belorussia each year with severe deformities and disabilities which are due to birth defects and hereditary conditions and have nothing to do with radiation. Similar rates occur throughout Europe. Between 40 and 80 such cases will involve severe limb deformities.”

-Dr Keith Baverstock, Radiation Scientist, World Health Organisation, Rome, letter to The Times, June 1995

“We did not find any correlation between radionuclear contamination [in five regions of Belarus] and perinatal and infant mortality rates.”

-Dr A M Petrova et al, ‘The health condition of pregnant women, newborns and first-year infants residing in territories contaminated with radionuclides’, Byelorussian Research, Maternity and Child Care Institute, 1995

“Any glance at general health trends in Belarus during the 1980s shows a continuing increase in cancer, leukaemia, perinatal mortality and many other health defects prior to the Chernobyl fallout. [It is] an unfortunate error to link the undeniably poor health of the population of parts of the Former Soviet Union to the Chernobyl accident.”

Dr Alexander Lutsko. International Sakharov Institute of Radioecology, Minsk, Belarus, and Dr Alan Flowers, Kingston University, June 1995

“A leading campaigner against official secrecy over Chernobyl, Professor Dmitri Grodzinski, told me that the stories [of hospitals lined with gaunt, dying and deformed children, as reported in The Sunday Times in 1990] were nonsense. He showed me magazines that had used photographs of thalidomide children to illustrate articles on Chernobyl.”

Piers Paul Read, author of Ablaze - the story of Chernobyl, in the Spectator, 17 April 1993
Bauxite Required for Different Energy Options

Alfred Voß, Ulrich Fahl, University of Stuttgart

kg / GWh