

The Role of Nuclear Power and Policy Implications for the Future of Energy

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Energy Supply Must Be Transformed

- Equitable development is more important than ever in the world of asymmetric threats
 - We know the poor are poor, and the poor know that they are poor. Sustained deprivation breeds resentment and conflict.
- Meeting the needs of the developing world will require expanding global energy supply by a factor of 4 or 5 between now and 2050
 - This even assuming previously unseen gains in efficiency
- To stabilize at an equivalent doubling of CO₂, this will require transforming the global energy system from 15% carbon-free to 50-80% carbon free by 2050.
 - Carbon free energy must grow by a factor of five to fifteen over the next 50 years (3% to 5% per year over the whole period).



Three Great Shifts in Energy Supply

It has taken 50 years for a new source to go from 10% to 60% of total supply.

- Firewood to Coal
 - 1850 to 1900 (50 years)
- Coal to Oil & Gas
 - 1925 to 1975 (50 years)
- Fossil Fuel to Carbon Free Sources
 - 2000 to 2050?
 - We are almost 10 years into this period
 - This is probably possible – but we really need to get moving



Sources of Carbon-Free Energy

300 to 900 EJ/y are needed

Energy Source	Primary Energy Production (EJ _p /y)			Natural flow or resource (EJ _p)
	2001	Potential by 2050	Long-term Potential	
Hydroelectric	28	40–60	60–100	400/y
Geothermal	0.7	5–10	5–20	10,000,000
Ocean	0.006	0–1	1–5	2,000,000/y
Nuclear fusion	0	0	?	4,000,000,000+
Nuclear fission	28	70–220	500+	10,000,000
Biomass	4*	50–150	50–500	2,000/y
Solar	0.2	50–150	500+	3,000,000/y
Wind	0.6	20–50	100–250	40,000/y
Decarbonized fossil	0	150+	500+	250,000

* Commercial biomass only; traditional biomass is variously estimated at 15–65 EJ/y.



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Difficult to Stabilize without Nuclear Fission

- Optimistic end of range for non-fission sources yields about 600 EJ/y
 - Need 300 to 900 – might or might not do
- Pessimistic end of range yields less than 350 EJ/y
 - This is unlikely to get the job done
- The 70 to 220 EJ/y from fission is critical to achieving the target.
 - The only major carbon-free source that is currently operating at a truly industrial scale.
 - Well suited to provide critical “base load” power.



Problems with Fission

- Accidents
- Waste
- Weapons Proliferation

All of these are greatly magnified when fission production is increased by a factor of 6 to 8 as may be required.

- Much of the new capacity is needed in the developing world

These problems are not to be dismissed, but must be weighed against the predicable destruction associated with catastrophic climate disruption.



New Approaches Needed for Expansion of Fission

- Need to maintain operational safety
 - Many more plants
 - Located in places like China, India, Indonesia, Pakistan, etc.
- Need to manage waste stream
 - May be desirable to rethink fuel cycle to reduce waste without increasing weapons materials
- Need to contain threat of nuclear weapons proliferation
 - Fuel reprocessing could become economically attractive
 - Bomb-grade plutonium is major byproduct of current reprocessing technology.



Internationalization of the Fuel Cycle

- IAEA Dir. Gen. El Baradei proposal (major points):
 - Restrict all processing of weapons-grade materials to facilities under multi-national control
 - Convert all HEU (bomb grade) reactors to LEU (non-bomb grade)
 - Provide reliable access to LEU for compliant countries
 - Advocate creation of multilateral agreements for disposal of waste
- This would go a long way toward containing weapons proliferation under expanded use.
- Would do less to address accidents or diversion of non-bomb grade material for use in “dirty bomb”



Thinking About the Long Term

- Internationally controlled “Energy Parks”
 - “Hub and Spoke” design
 - Contain all handling of nuclear materials
 - Produce long-life sealed core reactors
 - “Nuclear Batteries”
 - Probably using molten lead cooled design – perhaps pebble bed
 - Could be transported to place of use and “plugged in” for 15 to 20 years of generation
 - When exhausted, could be returned to Energy Park for refueling.
 - Guarantee access at a reasonable cost to nations that are meeting nuclear obligations
- This would require technical, institutional, and political progress
 - Magnitude of the climate change and nuclear proliferation issues make serious effort worthwhile



Hub and Spoke Concept

