Wind, Solar Generation Capacity Catching Up with Nuclear Power

Michael Renner | September 23, 2014

Advocates of nuclear energy have long been predicting a renaissance, yet this mode of producing electricity has been stalled for years.[1] Renewable energy, by contrast, continues to expand rapidly, even if it still has a long way to go to catch up with fossil fuel power plants, which account for roughly two thirds of world electricity production.[2]

Nuclear's share of global power production has declined steadily from a peak of 17.6 percent in 1996 to 10.8 percent in 2013.[3] Renewables increased their share from 18.7 percent in 2000 to 22.7 percent in 2012.[4] Hydropower was the leading source of renewable electricity (16.5 percent of global power in 2012), while wind contributed 3.4 percent and solar, 0.6 percent.[5] But wind and solar energy are the fastest growing electricity technologies worldwide. Between 2000 and 2012, wind power grew nearly 16-fold and solar jumped 49-fold.[6]

Nuclear's share of global power production was

10.8%

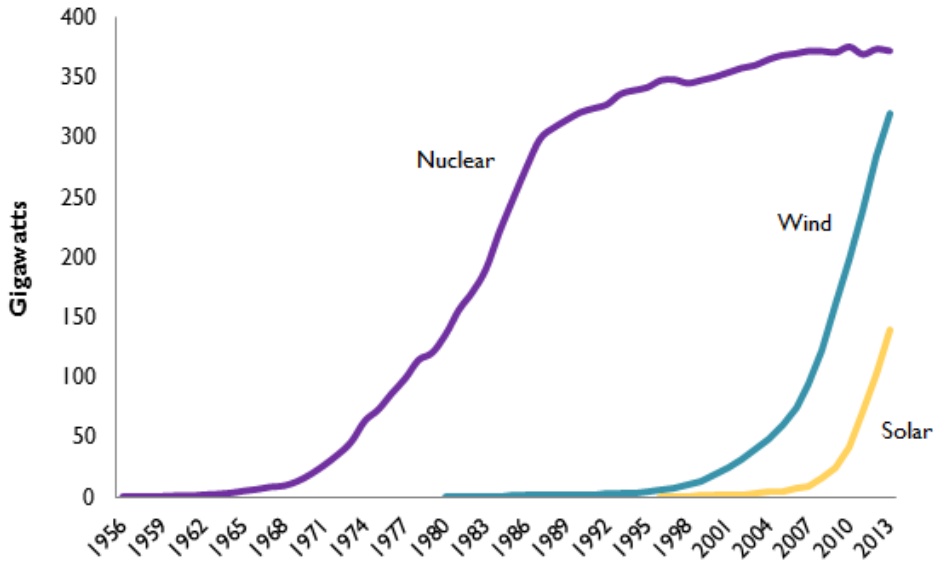
in 2013

From its beginnings in the mid-1950s, global nuclear power generating capacity rose rapidly and reached 298 gigawatts (GW) in 1987, an average annual growth of 9.3 percent.[7] In the following 23 years, however, only 77 GW of capacity were added to reach 375.3 GW, at a rate of 3.4 percent per year.[8] From this 2010 peak, capacity declined to 371.8 GW in 2013, according to the International Atomic Energy Agency (IAEA).[9] Adverse economics, concern about reactor safety and proliferation, and the unresolved question of what to do with nuclear waste have put the brakes on the industry.

The IAEA's figures actually paint a rosy picture. A critical assessment by the World Nuclear Industry Status Report comes up with lower capacity figures and a more precipitous decline from a 2010 peak of 367 GW to just 333 GW as of July 2014.[10] The difference is due to assessments of the effective operational status of reactors, principally those in Japan after the Fukushima disaster; 38 of that country's 48 reactors have not produced electricity in two and a half years.[11] The Status Report uses a concept called long-term outage (LTO), under which "a nuclear power reactor is considered in LTO if it has not generated any power in the entire previous calendar year and in the first semester of the current calendar year."[12]

In stark contrast, wind and solar power generating capacities are now on the same soaring trajectory that nuclear power was on in the 1970s and 1980s.[13] (See Figure 1.) Wind capacity of 320 GW in 2013 is equivalent to nuclear capacity in 1990.[14] The 140 GW in solar photovoltaic (PV) capacity is still considerably smaller, but growing rapidly.[15]

Figure 1. | **World Nuclear, Wind, and Solar Generating Capacity, 1956-2013**



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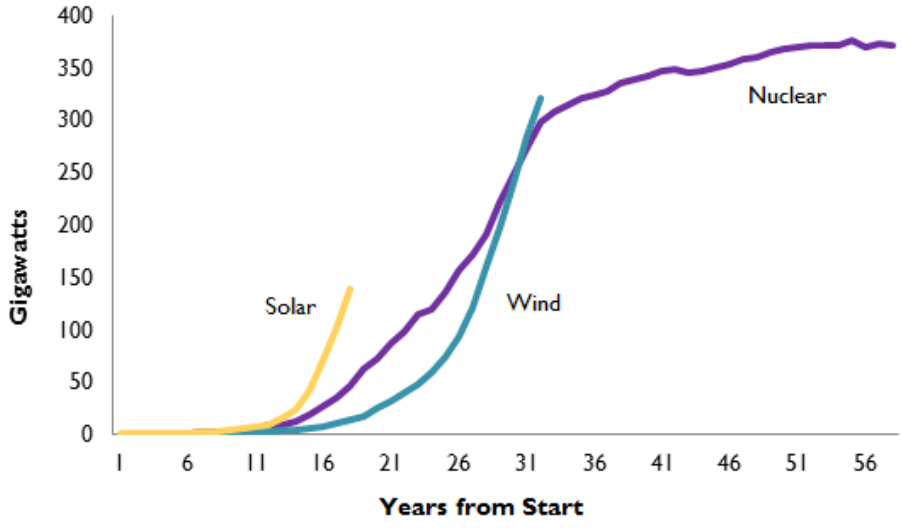
Plotting nuclear, wind, and solar PV trends from a common starting point allows a closer comparison.[16] (See Figure 2.) The growth in wind capacity at first lagged behind the expansion of nuclear installations, but then it started to grow faster and is now outpacing nuclear. Solar PV capacity has entered a dramatic upswing even more quickly than either nuclear or wind did. The nuclear and wind industries each took 12 years to move from about 5 GW of cumulative capacity to about 100 GW; solar accomplished this feat in just 7 years.[17]

A different picture emerges, however, with regard to electricity consumption from these sources.

Figure 2. | **World Nuclear, Wind, and Solar Generating Capacity, Comparison from Start**



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Although use of nuclear electricity has declined from a peak of 2,806 terawatt-hours (TWh) in 2006 to 2,489 TWh in 2013 (a slump of 11.3 percent), it still is four times larger than the use of wind power (628 TWh) and 20 times larger than solar power use (125 TWh).[18] (See Figure 3.) Yet consumption of electricity from all renewable sources—including hydropower, biomass, geothermal energy, and other sources—added up to 5,016 TWh in 2013, roughly double the amount of nuclear electricity.[19]

Wind and solar power are affected by a number of factors. There could be a time lag between completing the construction of a wind or solar farm and connecting it to the grid. In China, for example, solar PV capacity was added so quickly that it proved difficult to keep pace with grid connections, especially since many of the installations were in the sunny western parts of the country that are remote from the centers of electricity demand.[20]

A more fundamental factor is the intermittency of wind and solar resources. Compared with nuclear reactors, wind and solar facilities have a lower capacity factor—the amount of electricity actually produced compared with a facility's theoretical maximum. In the United States, nuclear reactors typically operate at between 85 and 90 percent of nominal capacity.[21] Solar PV plants tend to run at 16–28 percent and wind turbines at 30–45 percent.[22] However, renewable energy technologies continue to improve the effectiveness with which wind and sunshine are turned into power. The wind capacity factor has improved from 35 percent a decade ago to more than 50 percent for the latest designs.[23]

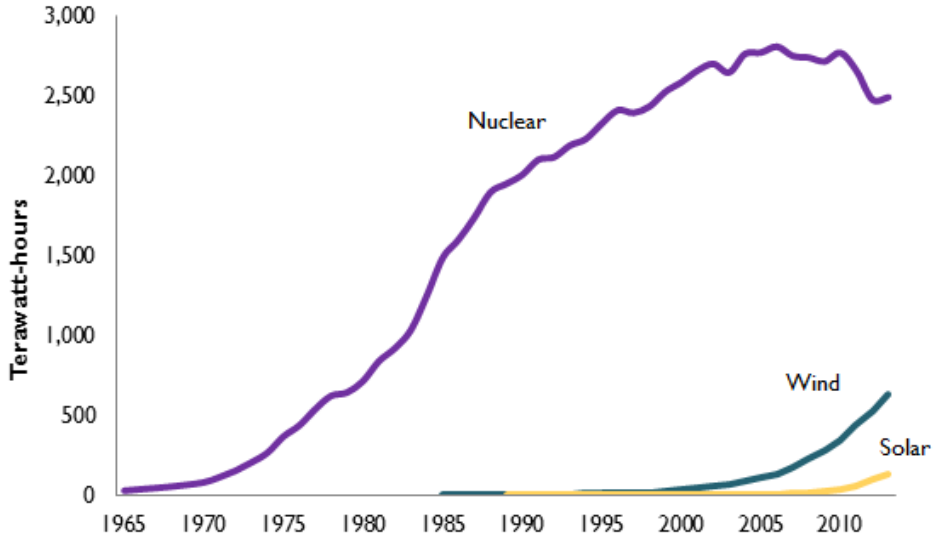
Nuclear reactors typically operate at

85-90%

of nominal capacity

In recent years, renewable energy attracted far greater investments than nuclear power did. According to estimates by the International Energy Agency (IEA), nuclear investments averaged $8 billion per year between 2000 and 2013, compared with $37 billion for solar PV and $43 billion for wind.[24] Total renewable electricity investments averaged $153 billion annually during the same period, thus surpassing even the $106 billion spent on fossil fuel power.[25] Including $212 billion for

Figure 3. | **World Nuclear, Wind, and Solar Electricity Consumption, 1965-2013**



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Source: BP

transmission and distribution systems, an average of $479 billion was invested annually in the power sector as a whole.[26] Individual countries, of course, set diverging priorities, but nowhere did nuclear have a major role in power generation investments.[27] (See Figure 4.)

While renewable energy is poised to continue its expansion, the solar PV industry and to a lesser degree the wind industry have experienced considerable turbulence in recent years. Falling costs and regional shifts in manufacturing have forced a realignment and consolidation among manufacturers, although lower prices were welcome news for project developers and installers.[28]

Mostly due to lower costs for equipment such as solar panels and wind turbines, investments have actually fallen in recent years, although industry volatility and uncertainty about government policies also contributed to this development.[29] Total investments in wind energy grew from $14.5 billion in 2004 to a peak of $94.8 billion in 2010 but then declined to $80.1 billion in 2013.[30] Solar PV investments grew from $12.1 billion in 2004 to a peak of $157.8 billion in 2011 and now stand at $113.7 billion.[31]

Nuclear energy attracted

51%

of total energy R&D spending between 1974

In contrast with investment priorities, research budgets still favor nuclear technologies. Among members of the IEA (most European countries, the United States, Canada, Japan, South Korea, Australia, and New Zealand), nuclear power has received the lion's share of public energy R&D budgets during the last four decades.[32] (See Figure 5.) Nuclear energy (both fission and fusion) attracted $295 billion, or 51 percent, of total energy R&D spending between 1974 and 2012.[33] But this number has declined over time, from a high of 73.6 percent in 1974 to 26 percent today.[34] Renewable energy received a cumulative total of $59 billion during the same period (10.2 percent).[35] But in contrast to nuclear power's declining trajectory, spending on renewables rose from just 2.8 percent of energy R&D in 1974 to 20.8 percent in 2012.[36]

Figure 4. | **Average Annual Investments in Power Generation, 2000-2013**

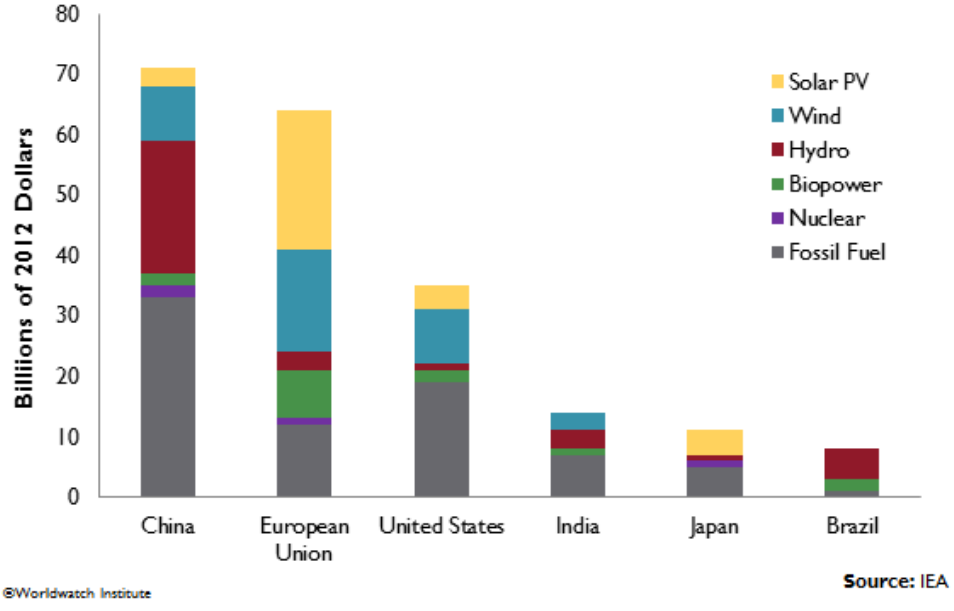
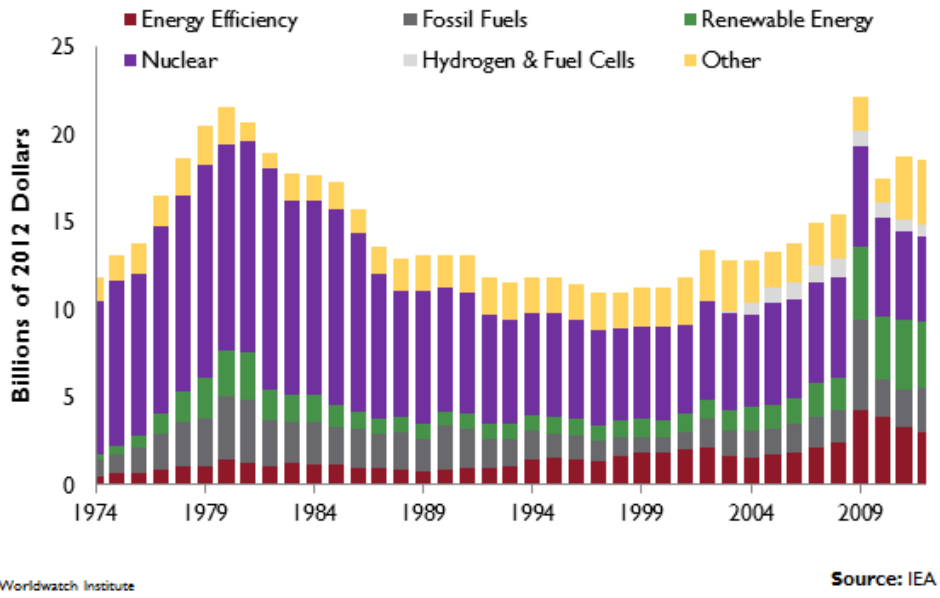


Figure 5. | **IEA Members' Energy R&D Budgets, 1974-2012**



Worldwide, government R&D for renewables ran to an estimated $4.6 billion in 2013, with another $4.7 billion in corporate R&D.[37] The combined $9.3 billion is up from $5.1 billion in 2004, but it falls short of the $9.7 billion spent in 2011.[38]

Because they can be deployed at variable scales and constructed in less time, wind and solar power are far more practical and affordable options for most countries than nuclear power reactors. Worldwide, 31 countries are operating nuclear reactors on their territories.[39] This compares to at least 85 countries that have commercial wind turbine installations.[40]

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countries are operating nuclear reactors on their

A small number of countries rely heavily on nuclear energy. The United States, France, Russia, South Korea, and China together account for 68 percent of all nuclear electricity generated worldwide.[41] But several other countries have decided to phase out their reactors or to cease constructing new ones. Among the nations with nuclear reactors, six countries now generate more power from renewables (even when large hydropower dams are excluded) than from nuclear power: Brazil, China, Germany, India, Japan, and Spain.[42] In Spain, wind power—accounting for 21 percent of the country's total electricity generation—outpaced nuclear for the first time in 2013.[43]

The chances of a nuclear revival seem slim. Renewable energy, by contrast, appears to be on the right track. But it is clear that renewables have a long way to go before they can hope to supplant fossil fuels as the planet's principal electricity source. The expansion of sources like wind and solar will have to become even more rapid in order to stave off climate disaster, and that in turn means that their fate cannot be left to the whims of the market alone.

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[1] World Nuclear Association, “The Nuclear Renaissance,” updated January 2014, at www.world-nuclear.org/info.
[2] U.S. Energy Information Administration, *International Energy Outlook 2013* (Washington, DC: 2013), Figure 83.
[3] Mycle Schneider et al., *The World Nuclear Industry Status Report 2014* (London: Mycle Schneider Consulting, 2014), p. 13.
[4] U.S. Department of Energy, *2012 Renewable Energy Data Book* (Washington, DC: 2013), p. 48.
[5] Ibid.
[6] Ibid., p. 41.
[7] BP, *BP Statistical Review of World Energy 2014* (London: 2014).
[8] Ibid.
[9] Ibid.
[10] Schneider et al., op. cit. note 3, p. 6.
[11] Ibid., p. 12.
[12] Ibid.
[13] International Atomic Energy Agency (IAEA), Power Reactor Information System (online database), "Nuclear Power Capacity Trend," at www.iaea.org/PRIS/WorldStatistics/WorldTrendNuclearPowerCapacity.aspx; Alexander Ochs and Michelle Ray, "Nuclear Power Recovers Slightly, But Global Future Uncertain," *Vital Signs Online*, 8 October 2013; BP, op. cit. note 7; Christopher Flavin, “Wind Energy Growth Continues,” in Worldwatch Institute, *Vital Signs 2001* (New York: W. W. Norton and Company, 2001), p. 47.
[14] BP, op. cit. note 7.
[15] Ibid.
[16] IAEA, op. cit. note 13; Ochs and Ray, op. cit. note 13; BP, op. cit. note 7; Flavin, op. cit. note 13.
[17] Author's calculation based on IAEA, op. cit. note 13, on Ochs and Ray, op. cit. note 13, on BP, op. cit. note 7, and on Flavin, op. cit. note 13.
[18] BP, op. cit. note 7.
[19] Calculated from ibid.
[20] REN21, *Renewables 2014 Global Status Report* (Paris: 2014), p. 47.
[21] Open Energy Information, “Transparent Cost Database,” at en.openei.org/apps/TCDB.
[22] Ibid.
[23] Zachary Shahan, **“**Wind Turbine Net Capacity Factor—50% the New Normal?” *Clean Technica*, 27 July 2012.
[24] International Energy Agency (IEA), *World Energy Investment Outlook* (Paris: 2014), Annex A.
[25] Ibid.
[26] Ibid.
[27] Ibid.
[28] International Renewable Energy Agency (IRENA), *Renewable Energy and Jobs* (Abu Dhabi: 2013).
[29] Schneider et al., op. cit. note 3, p. 74; IRENA, op. cit. note 28.
[30] Frankfurt School-UNEP Centre/BNEF, *Global Trends in Renewable Energy Investment 2014* (Frankfurt: 2014), p. 15.
[31] Ibid.
[32] Based on data in IEA, “Data Services,” online database, at wds.iea.org/WDS/Common/Login/login.aspx. Data include R&D for all energy purposes, not just the power sector.
[33] Ibid.
[34] Ibid.
[35] Ibid.
[36] Ibid.
[37] REN21, op. cit. note 20, p. 115.
[38] Ibid.
[39] Schneider et al., op. cit. note 3, p. 13.
[40] REN21, op. cit. note 20, p. 56.
[41] Schneider et al., op. cit. note 3, p. 14.

[42] Ibid, p. 73.
[43] Ibid.