

Averting the Danger of Catastrophic Climate Change: Is the Nuclear Renaissance Essential?

WNA Nuclear Century Outlook

The WNA's Nuclear Century Outlook is:

- ▶ A conceptualization of nuclear power's potential worldwide growth in the 21st Century; and
- ▶ An evaluation of nuclear energy's environmental contribution.

The Outlook is unique in nature and scope. Many nuclear projections extend just to 2030 and assume business-as-usual behaviour. The Outlook encompasses these scenarios but looks further into the future - with both optimistic and pessimistic assumptions.

In gauging nuclear energy's potential growth and environmental role, the Nuclear Century Outlook also offers perspective on two questions:

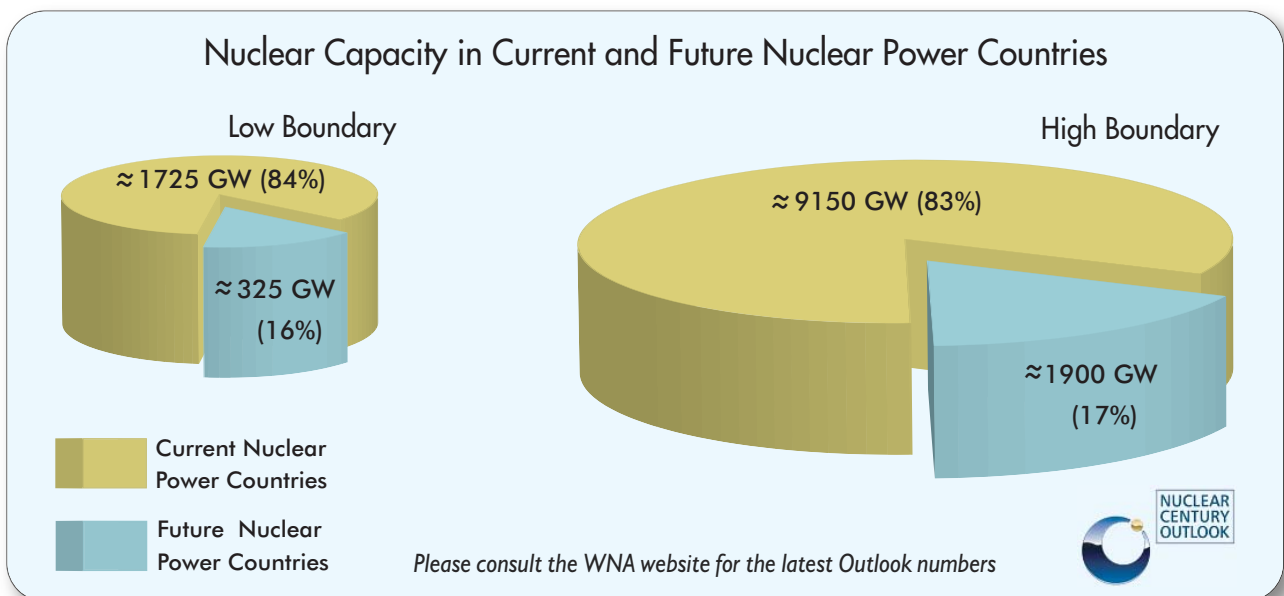
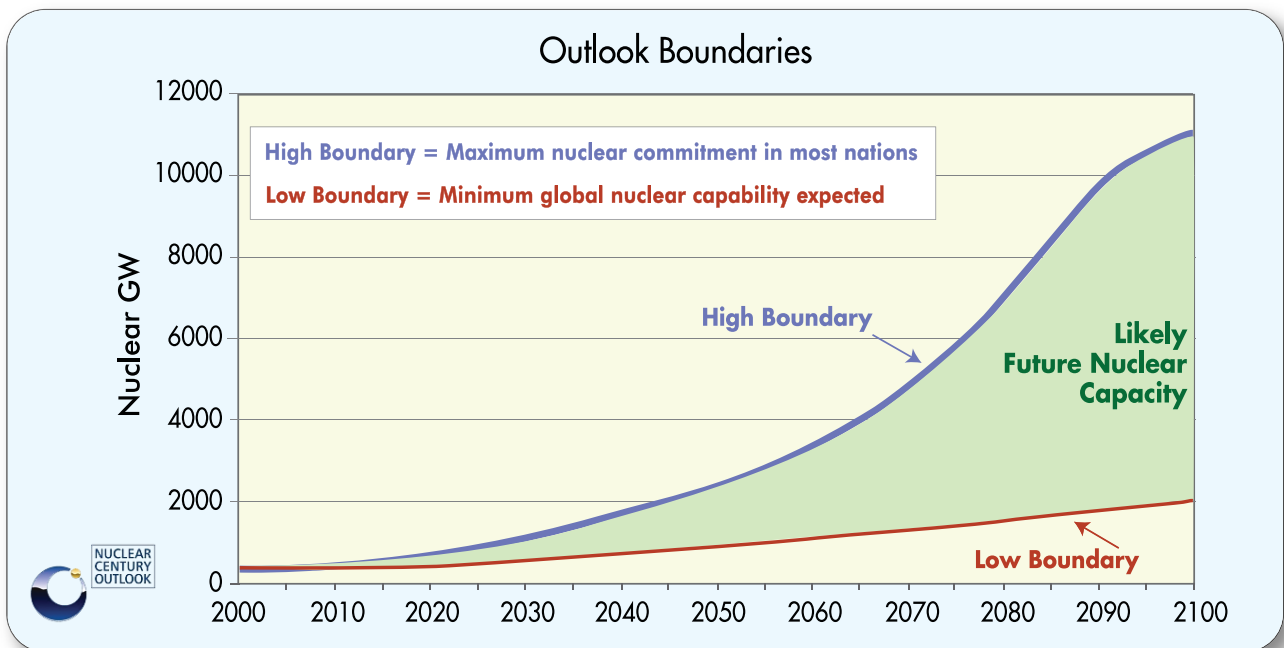
- ▶ Will nuclear energy's contribution depend heavily on introducing nuclear power into new nations?
- ▶ In meeting global clean-energy need, what is the relationship between nuclear power and renewable energy technologies?

The Outlook is built on country-by-country assessments of the growth potential of national nuclear programmes, based on estimates of need and capability, with projected population a key factor. For each country, the Outlook posits upper and lower growth trajectories, with the low reflecting the minimum nuclear capacity expected and the high assuming a full policy commitment to nuclear power. When summed globally, these trajectories yield boundaries within which the future is likely to fall.

WNA NUCLEAR CENTURY OUTLOOK							
MAJOR NUCLEAR PROGRAMMES*	2008	2030 Low	2030 High	2060 Low	2060 High	2100 Low	2100 High
<i>Units - 1 GWe</i>							
Belarus	0	2	5	5	8	5	10
Belgium	6	6	8	8	10	8	22
Brazil	2	10	30	40	100	70	330
Bulgaria	2	4	7	5	7	5	7
Canada	13	20	30	25	40	30	85
China	9	50	150	150	750	500	2800
Czech Republic	3	5	7	5	12	5	15
Finland	3	5	7	8	10	8	11
France	63	65	75	80	110	80	130
Germany	20	20	50	40	80	80	175
Hungary	2	4	5	4	8	5	12
India	4	20	70	60	350	200	2750
Japan	48	55	70	80	140	80	200
Lithuania/ Latvia/ Estonia	1	4	6	5	8	5	8
Netherlands	1	1	5	7	20	10	35
Romania	1	4	10	5	20	10	25
Russia	22	45	80	75	180	100	200
Slovakia	2	3	4	4	5	5	7
Slovenia	1	1	1	1	2	1	2
South Korea (& North Korea)	18	25	50	45	80	70	145
Spain	7	8	20	20	50	25	60
Sweden	9	10	15	10	18	10	18
Switzerland				5	10	5	11

The WNA secretariat maintains this analysis through an on-going dialogue with the WNA's worldwide industry membership and with experts in leading energy organizations, including IEA, WEC, IAEA and OECD-NEA. The secretariat welcomes advice from all quarters as it continues to update the Outlook analysis.

The latest Outlook tabulation can be seen on the WNA website.



These aspects of the Outlook bear emphasis:

- ▶ The low and high global trajectories are not growth “scenarios” as such, but rather the boundaries of a domain of likely nuclear growth.
- ▶ Even the low boundary of about 2,050 GW represents more than a five-fold increase over today’s nuclear capacity of 370 GW.
- ▶ Growth within the Outlook boundaries is postulated on the assumption that fuel availability will pose no constraint in operating a much larger global nuclear fleet. Most experts support this view on the grounds that a combination of factors – new ore discoveries, advanced mining techniques, use of uranium “tailings”, more reprocessing, introduction of the thorium fuel cycle and, ultimately, employment of breeder reactors – will ensure ample and affordable nuclear fuel supplies into the distant future.
- ▶ The Outlook country projections are implicitly based on the assumption of global environmental stability. This assumption will be vitiated if and as the pace of worldwide conversion to clean-energy technologies proves insufficient to avert catastrophic climate disruption. The essential goal of the Nuclear Century Outlook is to assess and demonstrate the pace of global nuclear growth necessary to prevent that outcome.

The Central Challenge: Decarbonizing Energy

How do the nuclear capabilities projected in the WNA Nuclear Century Outlook relate to the global environmental challenge? In short, how essential is the contribution from nuclear energy in the 21st Century?

Today a global population of 6.6 billion is rising toward 9 billion by 2050, as energy demand grows explosively to meet human needs and aspirations worldwide. The current path is unsustainable. The UN panel composed of the world's leading Earth scientists (IPCC) warns that global greenhouse gas (GHG) emissions must, by 2050, be cut by 70% to avert catastrophic change in our planet's climate system. Achieving emissions cuts on this scale will require sweeping technological change in the world economy.

Emissions-reduction strategy must be comprehensive, embracing conservation and efficiency, plus pervasive changes in industrial processes, farming and forestry. But the central task must be a global transformation in energy - because most GHG's come from the use of fossil fuels. The crucial challenge in GHG curtailment is to decarbonize an ever-expanding worldwide energy system.

Components of a Clean-Energy Future

Fundamental questions remain about future clean-energy technologies:

- ? **Future Transport:** What will be the comparative efficacy of advanced batteries vs. hydrogen fuel cells?
- ? **Clean Fossil Fuel:** Will large-scale Carbon Capture and Storage (CCS) prove feasible, affordable and sustainable?
- ? **Renewables Technology:** Can New Renewables (wind, solar, biomass, geothermal, tidal) overcome obstacles of cost and intermittency to contribute on a major scale?

Despite these technological unknowns, the essential components of a global clean-energy economy are already well understood:

1) More and Cleaner Electricity:

- ▶ Full transformation of electricity to emissions-free technologies
- ▶ Greater use of electricity in industrial processes and heating
- ▶ Electrification of transport (trains & battery-powered cars).

2) New Elements (using clean electricity or clean heat):

- ▶ High-efficiency, zero-emission plants producing a combination of heat and power (CHP)
- ▶ Desalination of sea water to meet an intensifying world water crisis
- ▶ Hydrogen production for fuel cells.

Future "Global Clean-Energy Need" can be projected as the combined output for clean "EHDH":

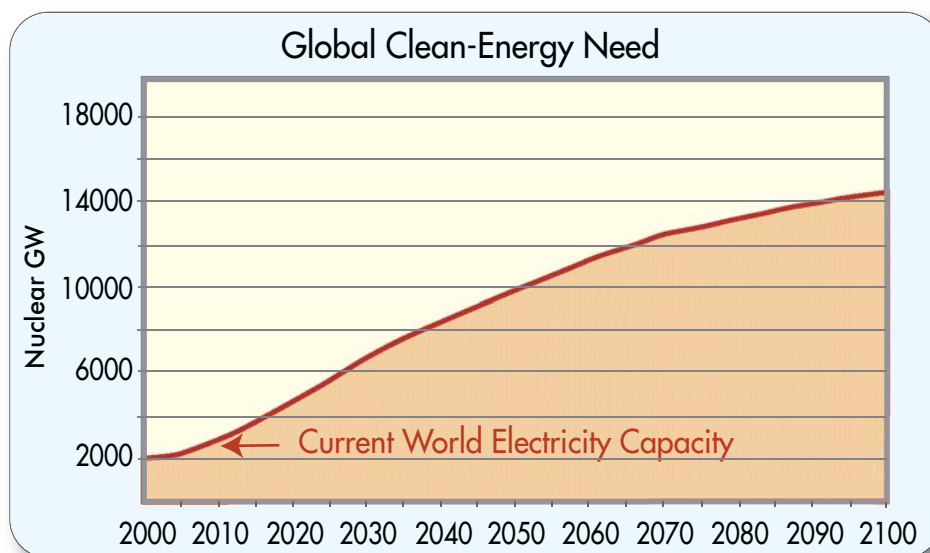
- Clean **E**lectricity (including battery power)
- Clean **H**eating (process and factory/office/home)
- Clean **D**esalination
- Clean **H**ydrogen production.

Quantifying Clean-Energy Need

As a unit of measure in projecting global EHDH-Need and capability, the Outlook uses “Nuclear Gigawatt” - the energy delivery capacity of a 1,000 MW reactor. To project global clean-energy need, the Outlook:

- ▶ Takes as a numerical starting point for EHDH-Need the urgent necessity to de-carbonize world electricity consumption (which in 2000 equated to 2,000 Nuclear GW).
- ▶ Accepts energy analysts’ expectation that global energy use will double between 2000 and 2050, while electricity consumption triples or quadruples.
- ▶ On the additional assumption that clean Heating, Desalination and Hydrogen will become substantial, posits a **five-fold increase in EHDH-Need by 2050**.
- ▶ Assumes that growth in EHDH-Need then slows, growing 40% in 2050-2100, as global population stabilizes at about 9 billion while economic development continues.

This approach yields an estimate of Clean-Energy Need at mid-century of about 10,000 Nuclear GW, rising by a further 40% in 2100. This means that our world will be chasing a clean-energy target that is receding - in effect, running away as we strive to reach it.



This order-of-magnitude estimate of future Clean-Energy Need gains credence from an alternative calculation. Today the IEA judges nuclear power’s 370 GW to represent 6.3% of world primary energy consumption. If so, world energy consumption equates to 5,875 Nuclear GW. If total energy consumption doubles by 2050, 85% of energy must be supplied by clean technologies in order to attain a 70% GHG cut from 2000 levels. On that basis, Clean-Energy Need in 2050 would be 9,990 Nuclear GW.

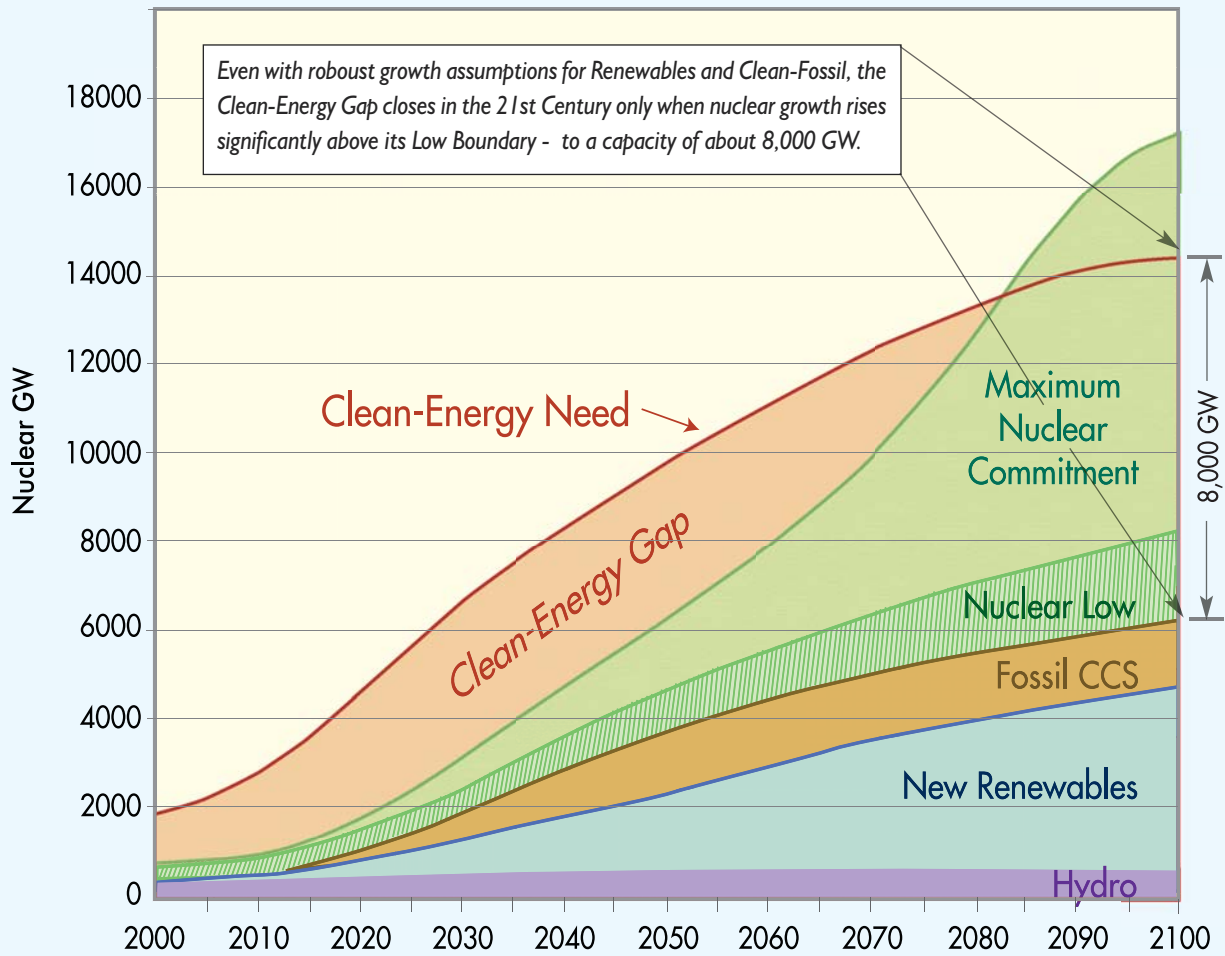
Supplying Clean-Energy Need

To place nuclear projections into context, the Outlook makes these assumptions concerning **overall clean-energy delivery** in the 21st Century:

- ▶ Hydropower growth stops at mid-century.
- ▶ New Renewables grow steadily and robustly, to a capacity by 2100 that is more than double the total of today’s world electricity output.
- ▶ Fossil Carbon Capture and Storage (CCS) makes a substantial contribution during the 21st Century, serving as a bridge technology, but does not grow indefinitely.
- ▶ Nuclear grows within the range defined by the WNA Outlook boundaries.

These assumptions, which are incorporated into the following graph, are highly favourable to the prospects for New Renewables, which today contribute only negligibly, and CCS technologies, which today are still unproven.

Global Clean-Energy Need & Supply



Implications for Global Strategy

The WNA Nuclear Century Outlook, although speculative, is fair-minded in design, draws heavily on respected expert analysis, and serves to underscore the full magnitude and urgency of the global environmental challenge. The Outlook carries important implications for strategy and action:

- ▶ While new countries can and should introduce nuclear energy, over 80% of nuclear growth – and thus most of nuclear technology’s environmental contribution – will occur in nations already generating nuclear power.
- ▶ Even with expansive growth in nuclear power, renewables will also be needed on a large scale, despite their higher cost. In this sense, nuclear and renewables are not competitors but clean-energy partners.
- ▶ Conversely, even if renewable and clean-fossil technologies meet extremely optimistic assumptions, a global clean-energy revolution adequate to avert catastrophic climate change will require an enormous contribution from nuclear power and extensive realization of its worldwide growth potential.

The World Nuclear Association is the international private-sector organization **supporting the people, technology, and enterprises** that comprise the global nuclear energy industry.

WNA members include the full range of enterprises involved in producing nuclear power – from uranium miners to equipment suppliers to generators of electricity.

With a secretariat headquartered in London, the **WNA serves as a global forum** for industry experts and as an authoritative information resource on nuclear energy worldwide.

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