Nuclear Power: The Jobs Myth

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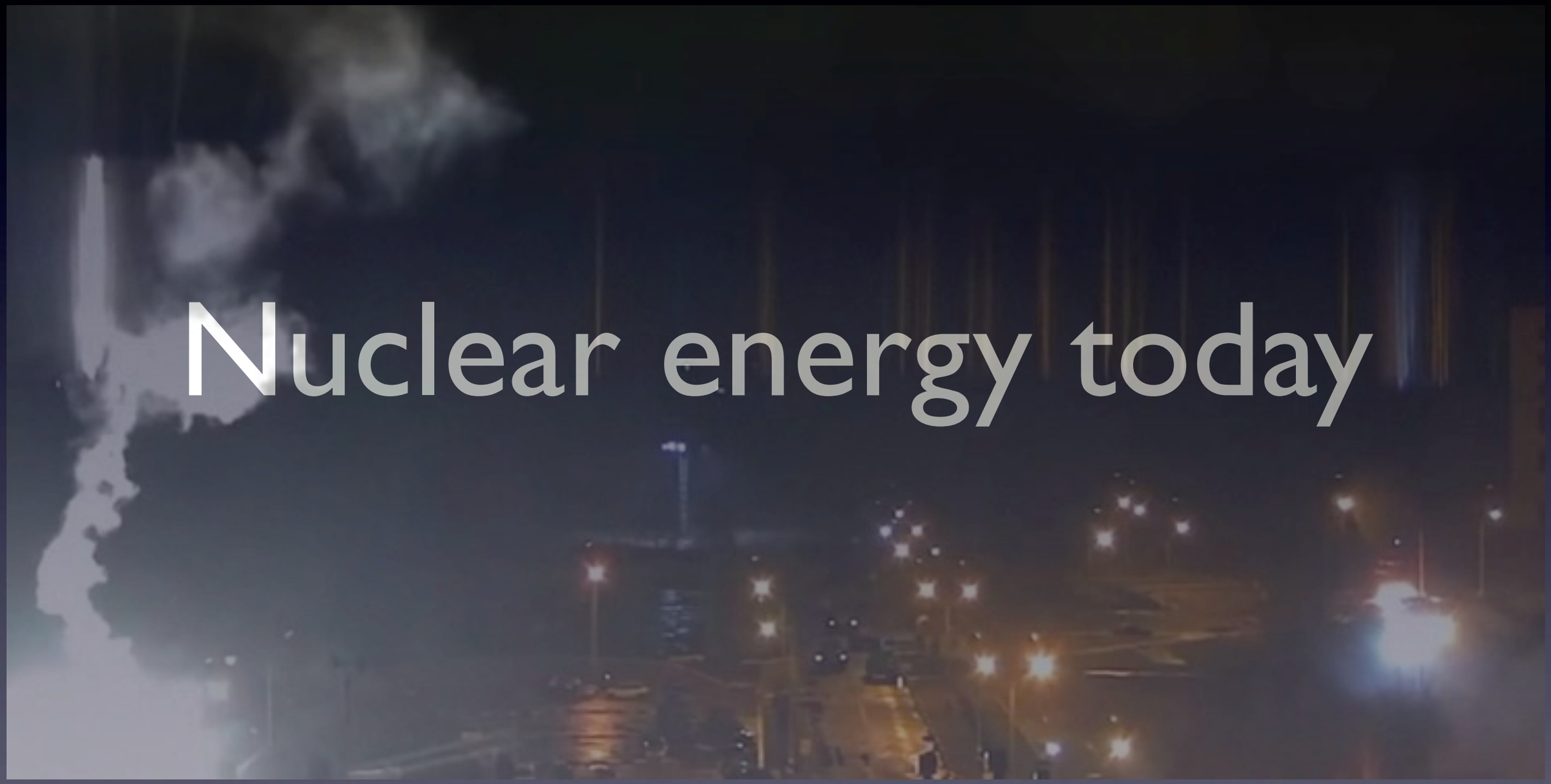
Campaign for Nuclear Disarmament Webinar
9 May 2022

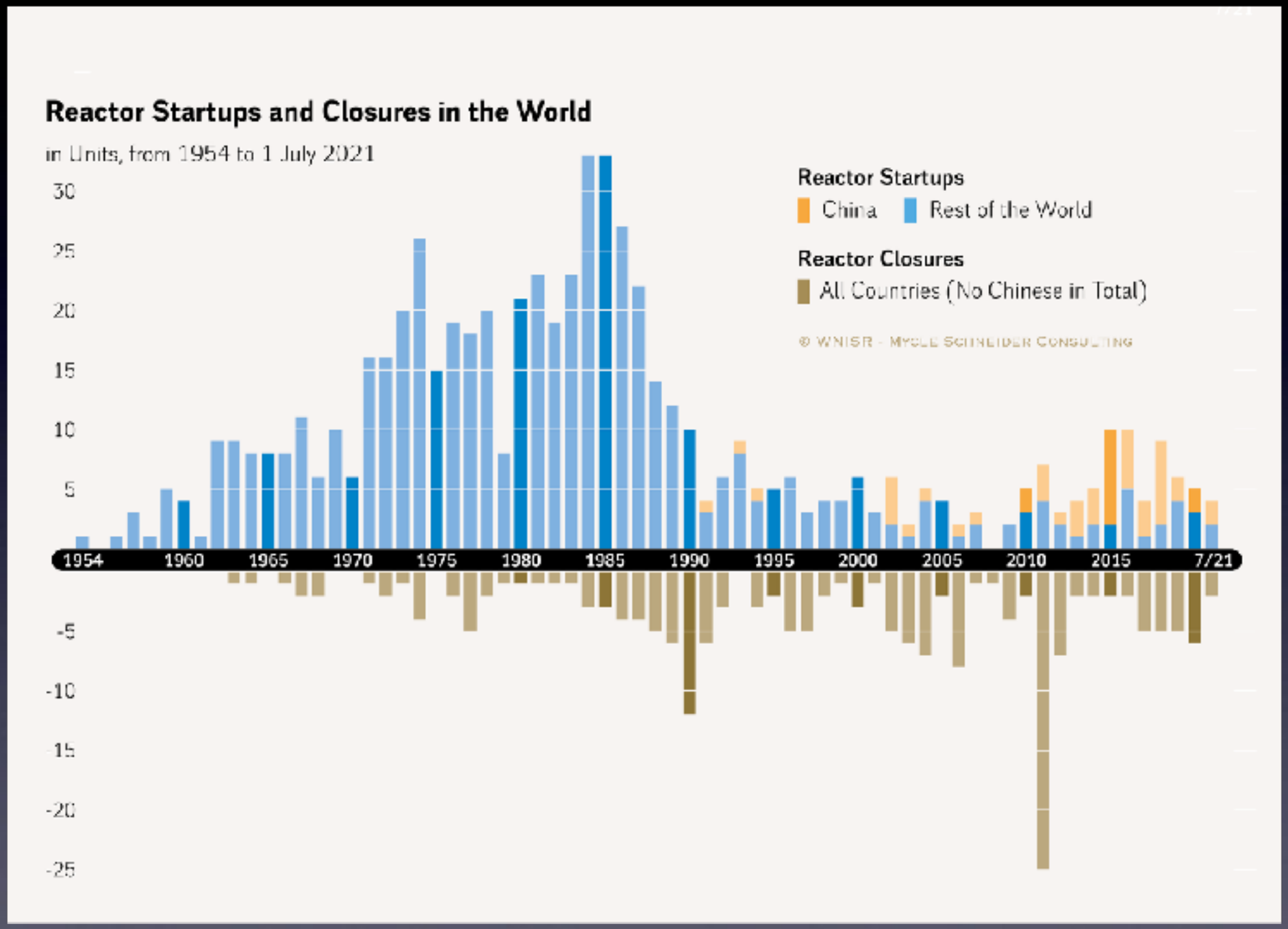
Drawing by Ulrike Zöllner , 2021, published in:
Abolmaesumi, Purang, Jennifer Black, Lara Boyd, Carrie Jenkins, Hoi Kong, M. V. Ramana, Steven Reynolds, Michelle Stack, Sheila Teves, and Y.-Dang Troeung. Chromatic: Ten Meditations on Crisis in Art and Letters. Vancouver: Peter Wall Institute for Advanced Studies, 2021.

Nuclear energy today



Source: https://media.farsnews.ir/Uploaded/Files/Images/1400/12/16/14001216000113_Test_PhotoN.jpg

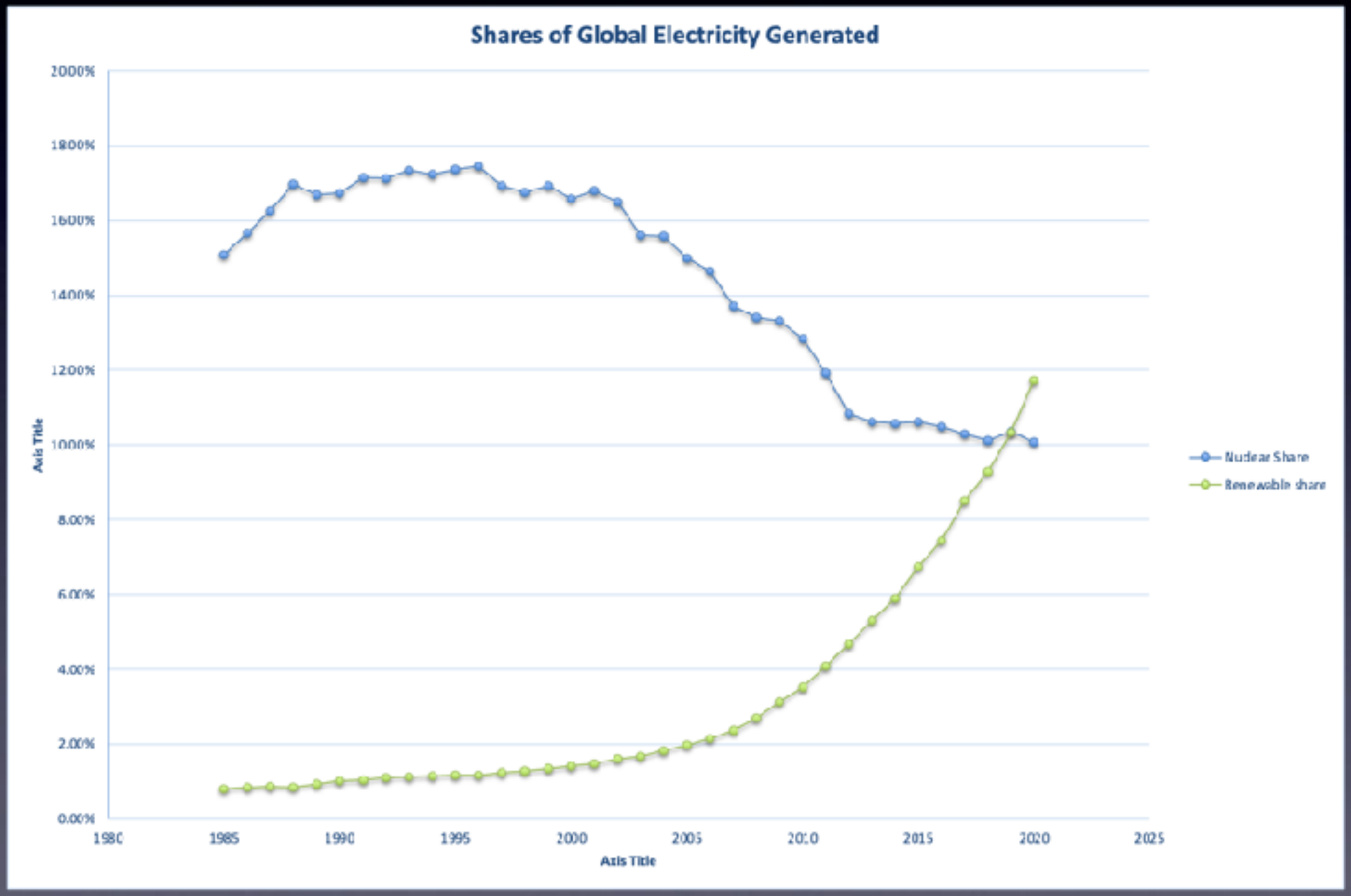
The best days of nuclear construction are over three decades ago



Source: World Nuclear Industry Status Report, 2021, Mycle Schneider Consulting.

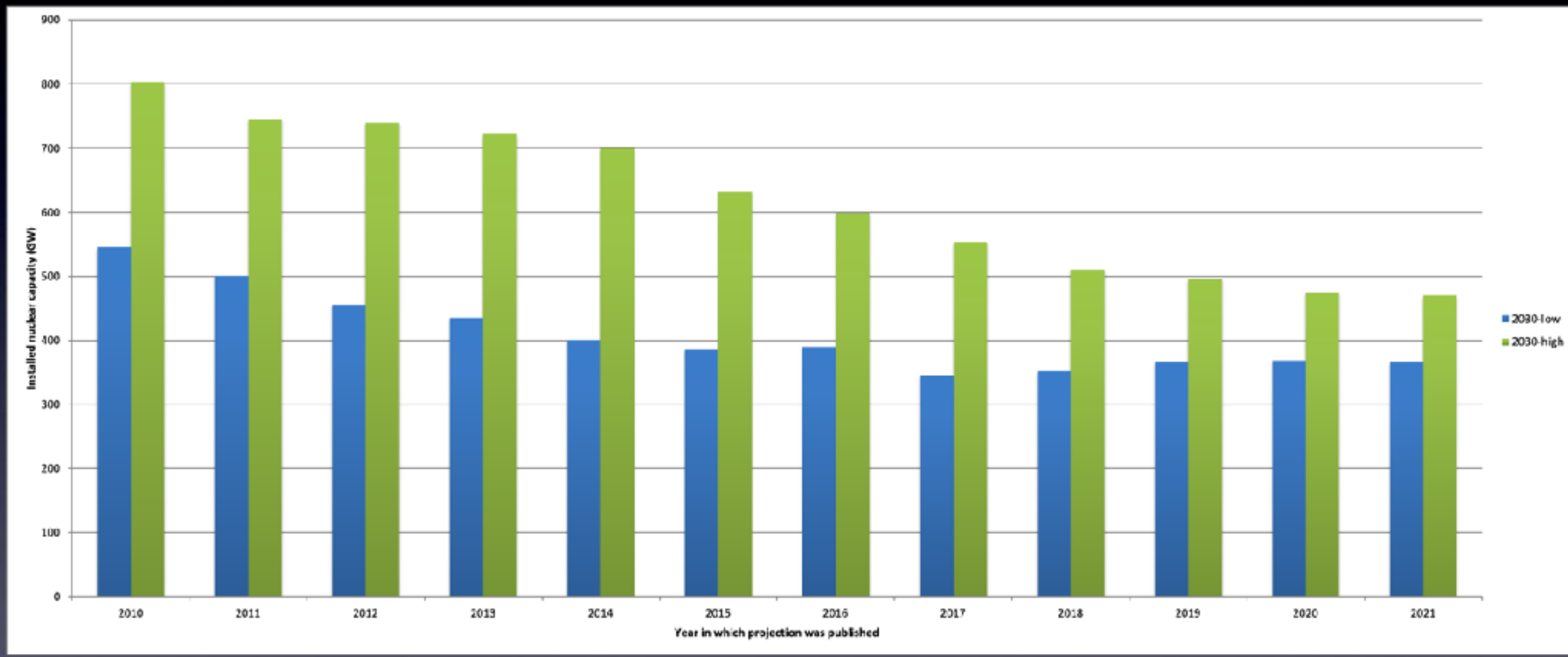
Share of Electricity

About 40 percent below historical maximum of 17.5 percent in 1996

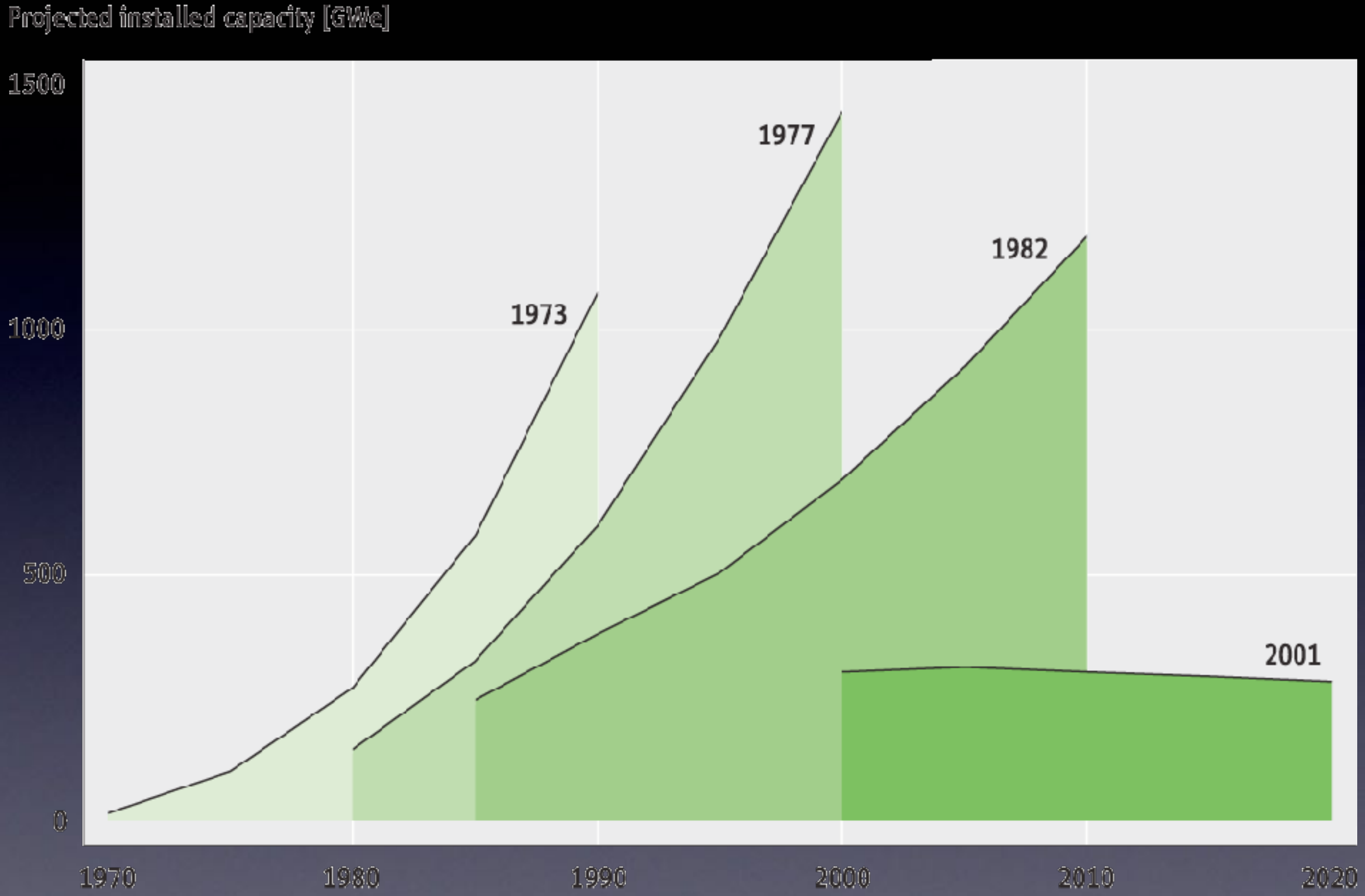


Source: Calculations using data from BP's Statistical Review of World Energy 2021

IAEA Projections



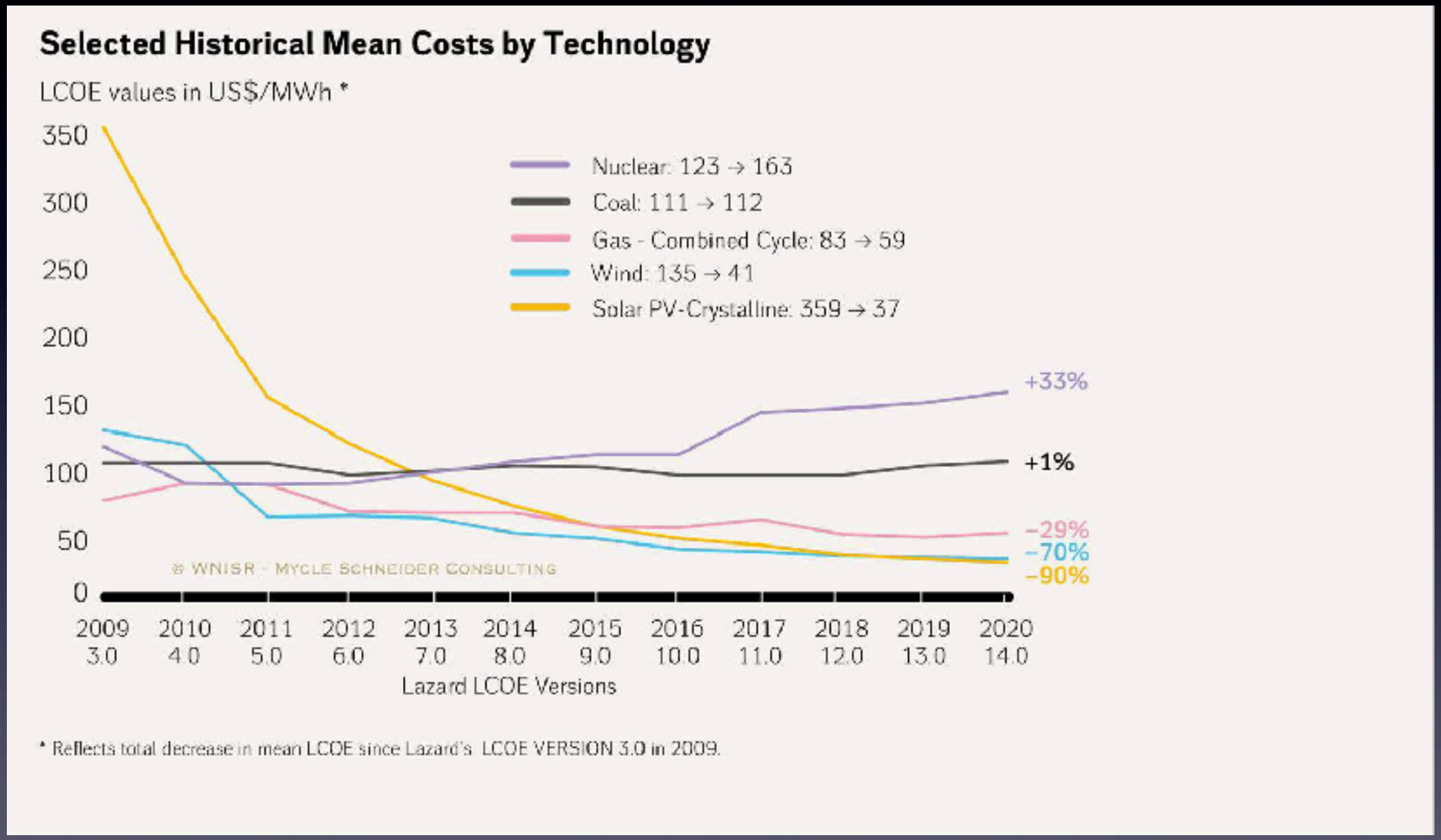
IAEA (2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021) Energy, Electricity and Nuclear Power Estimates for the Period up to 2050. Vienna, International Atomic Energy Agency.


Projected installed capacity [GWe]
1500
1000
500
0
1973
1977
1982
2001
1970
1980
1990
2000
2010
2020

Why this trend?

Nuclear power is not economically competitive: reactors cost too much to build

Other sources of electricity are cheaper… and becoming cheaper



Source: data from Lazard, as plotted in World Nuclear Industry Status Report 2021

Source: Lazard. "Levelized Cost of Energy v15," October 2021

Several reactors shutting down because of high operational costs and cheap alternatives

Another Reactor Closes, Punctuating New Reality for U.S. Nuclear Power

As Vermont Yankee shuts down, the U.S. has yet to address industry issues that span decades.

By Christina Nunez, National Geographic

PUBLISHED JANUARY 01, 2015

wnn world nuclear news

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Sweden's Oskarshamn 1 and 2 reactor units to close

14 October 2015

German utility Eon has decided that units 1 and 2 of the Oskarshamn nuclear power plant in Sweden will be shut down permanently. Unit 3 is unaffected by the decision, which was announced today by OKG AB, of which the EOn group is the major shareholder.

Related Stories

- EOn supports early closure of Oskarshamn units
- Court leaves Swedish nuclear tax unchanged

WNA Links

- Oskarshamn 1
- Oskarshamn 2
- Oskarshamn 3
- Nuclear Energy in Sweden

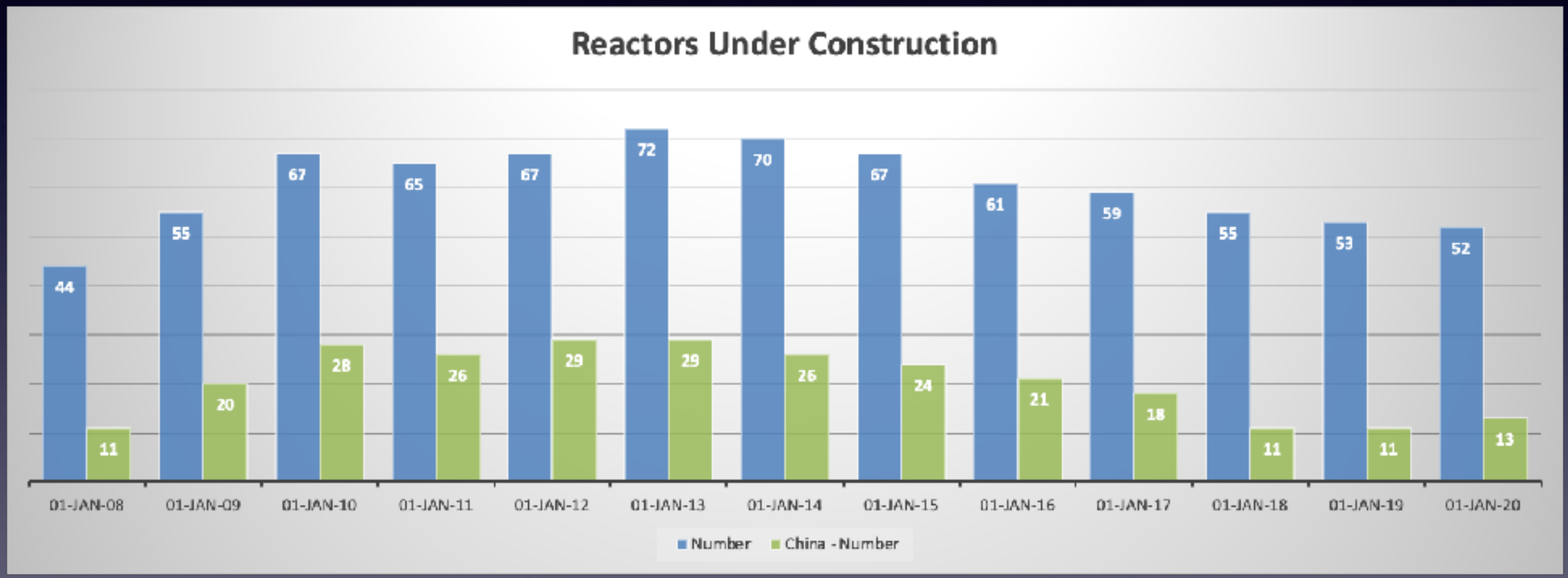
Related Links

- EOn
- OKG

The three-unit Oskarshamn plant (Image: OKG)

http://news.nationalgeographic.com/news/energy/2015/01/150101-vermont-yankee-shutdown-us-nuclear-issues/

Nuclear Renaissance



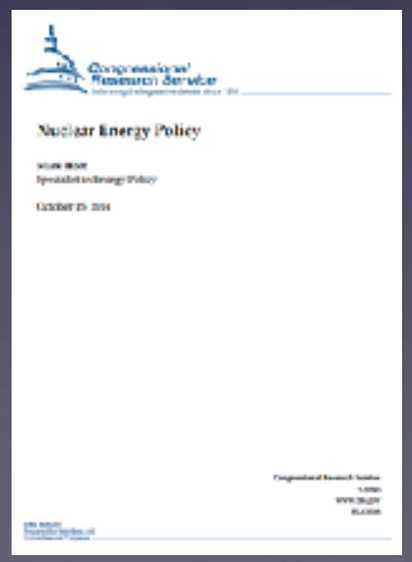
Source: My calculations, based on IAEA PRIS data

Nuclear Renaissance - USA

What was expected

Around 30 reactors ordered

Nearly 15 GW of new capacity before 2021


Congressional Research Service

Nuclear Energy Policy

What Materialized

Only 4 reactors began construction

2 reactors abandoned after $9 billion spent

What's left?


David Schlissel, Director of Resource Planning Analysis
January 2022

Institute for Energy Economics and Financial Analysis
IEEFA.org

Southern Company's Troubled Vogtle Nuclear Project

Units 3 and 4 Now Expected to Cost More Than $30 Billion and Are at Least Six Years Behind Schedule

Nuclear Renaissance - UK

Nuclear power

Brown calls for eight new nuclear plants

- New stations to be part of 'nuclear renaissance'
- Oil price fears and climate change push agenda

Michael White
Mon 14 Jul 2008 00.01 BST

Britain must build "at least" eight new nuclear power stations during the next 15 years to replace its ageing plants and contribute to a "post-oil economy" that is cleaner and much more efficient in its use of energy and careless pollution", Gordon Brow

The Telegraph

News | Business | Sport | Opinion | Politics | World | M


Business and Industry Secretary John Hutton speaks to A
Sizewell B

Ten UK nuclear power stations by 2020

By Andrew Porter and Charles Clover
10 January 2008 • 7:00pm

Proponent	Site	Type	Capacity (MWe gross)	Start-up
EDF Energy[1]	Hinkley Point C, Somerset	EPR x 2	3340	Lnd 2017 & mid-2019
EDF Energy[1]	Sizewell C, Suffolk	EPR x 2	3340	2020 & 2022
Horizon (RWE + E.ON)	Oldbury B, Gloucestershire	EPR x 2 or AP1000 x 3	3340-3750	2022
Horizon (RWE + E.ON)	Wylfa B, Wales	EPR x 3 or AP1000 x 4	Approx 5000	2020
NuGeneration (Iberdrola, GDF Suez, Scottish & Southern)	Sellafield, Cumbria	?	Up to 3600	2023
Total planned & proposed			**Up to approx 19,000 MWe**	

According to World Nuclear Association, April 2011

The WNA Reactor Database has 4 EPRs as 'planned' (6680 MWe) and 9 units (12,000 MWe) 'proposed'

Hinkley Point C Cost has gone up from 16 to 22 billion pounds

"EDF will turn on its first nuclear plant in Britain before Christmas 2017 because it will be the right time…It is the moment of the power crunch. Without it the lights will go out." Vincent de Rivaz, EDF, 2007.

Will Small Modular (Nuclear) Reactors solve the problems of nuclear power?


BULLETIN OF THE ATOMIC SCIENTISTS
2021, VOL. 77, NO. 4, 207–214
https://doi.org/10.1080/00963402.2021.1941600

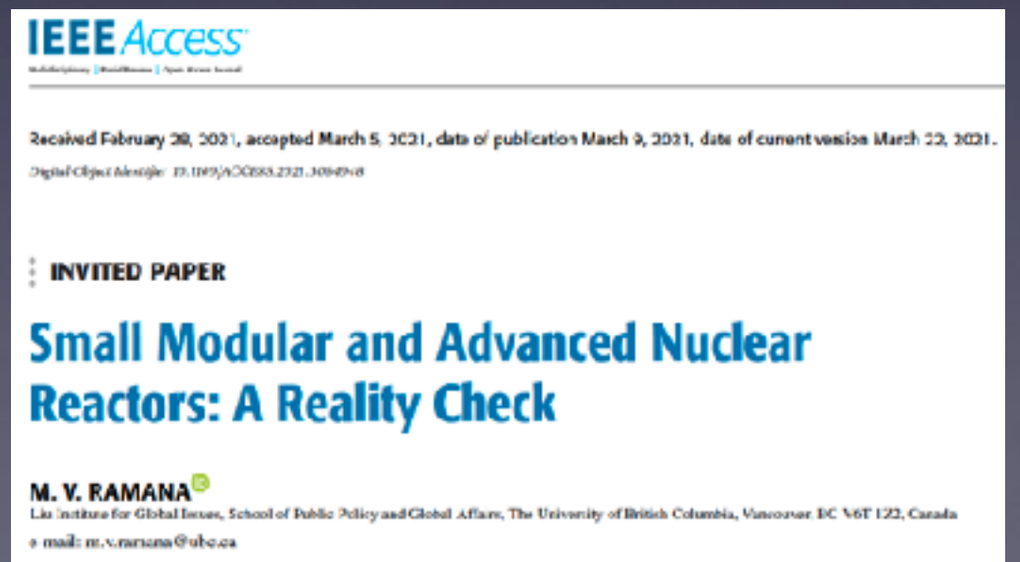
Routledge
Taylor & Francis Group

OTHER FEATURES

Check for updates

Can small modular reactors help mitigate climate change?

Arjun Makhijani and M. V. Ramana


IEEE Access

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INVITED PAPER

Small Modular and Advanced Nuclear Reactors: A Reality Check

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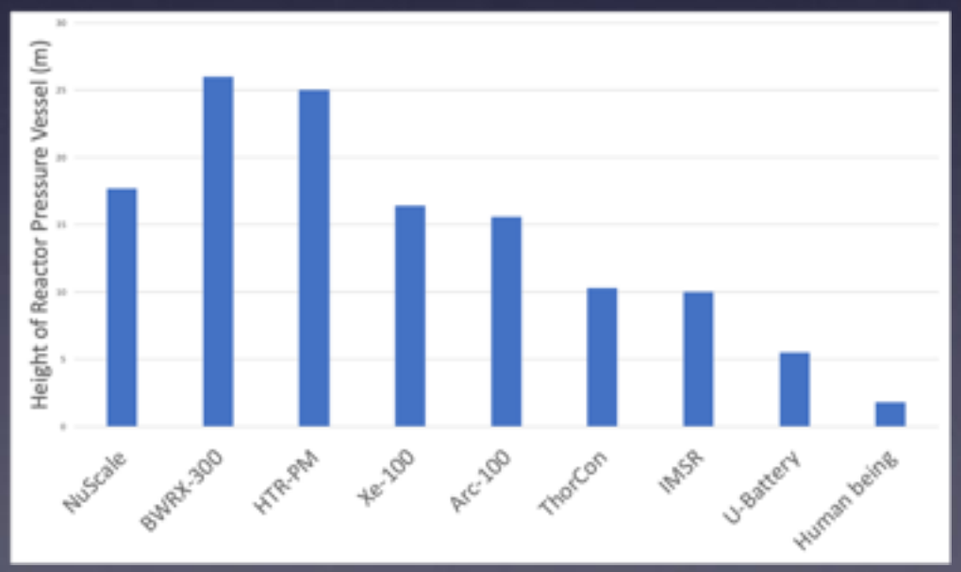
e-mail: m.v.ramana@ubc.ca

What are Small Modular Reactors?

	Capacity
Small	< 300 MWe
Medium	300 to 700 MWe



Assembled from factory-fabricated modules

Each module represents a portion of finished plant

All properties will not be realizable in a single design

Energy Research & Social Science 2 (2014) 115–124

Contents lists available at ScienceDirect

Energy Research & Social Science

journal homepage: www.elsevier.com/locate/erss

Original research article

One size doesn't fit all: Social priorities and technical conflicts for small modular reactors

M.V. Ramana*, Zia Mian

Nuclear Futures Laboratory and Program on Science and Global Security, Princeton University, United States

Small also means…

More cost

$$\frac{K_1}{K_2} = \left(\frac{S_1}{S_2}\right)^{0.6}$$

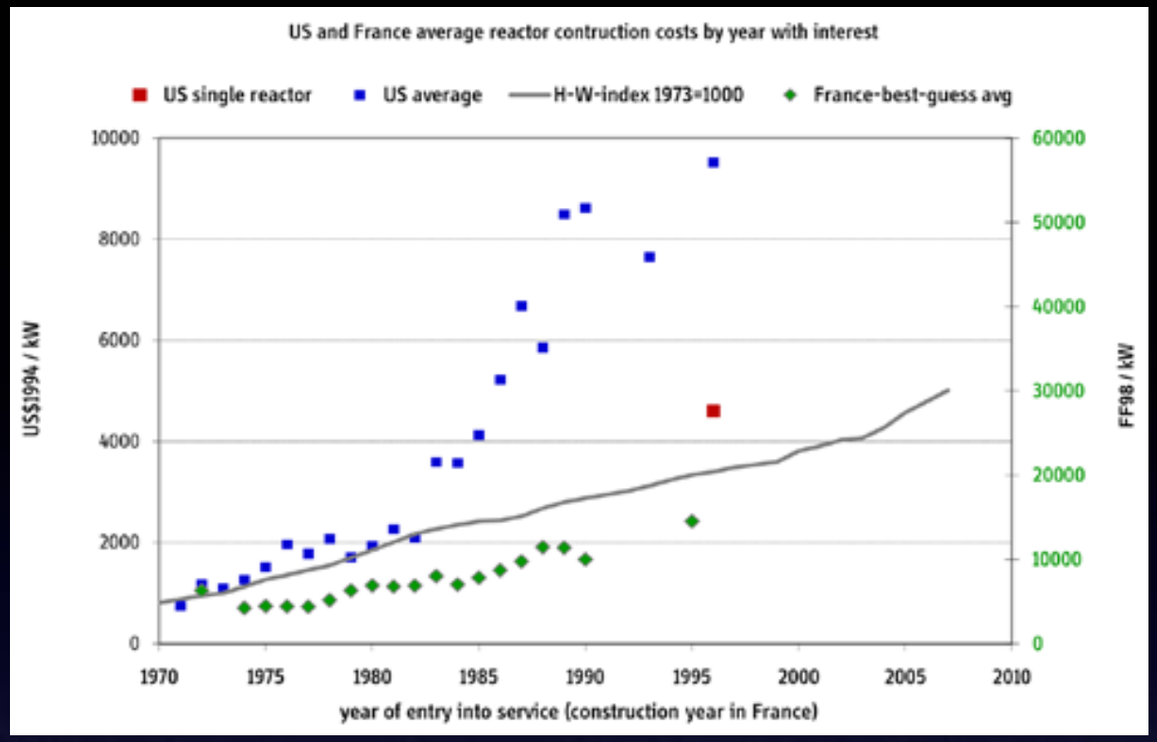
More spent fuel/waste/ proliferation risk

RESOURCE REQUIREMENTS AND PROLIFERATION RISKS ASSOCIATED WITH SMALL MODULAR REACTORS

ALEXANDER GLASER,* LAURA BERZAK HOPKINS, and M. V. RAMANA

NUCLEAR TECHNOLOGY VOL. 184 OCT. 2013

"Learning" might make plants more expensive



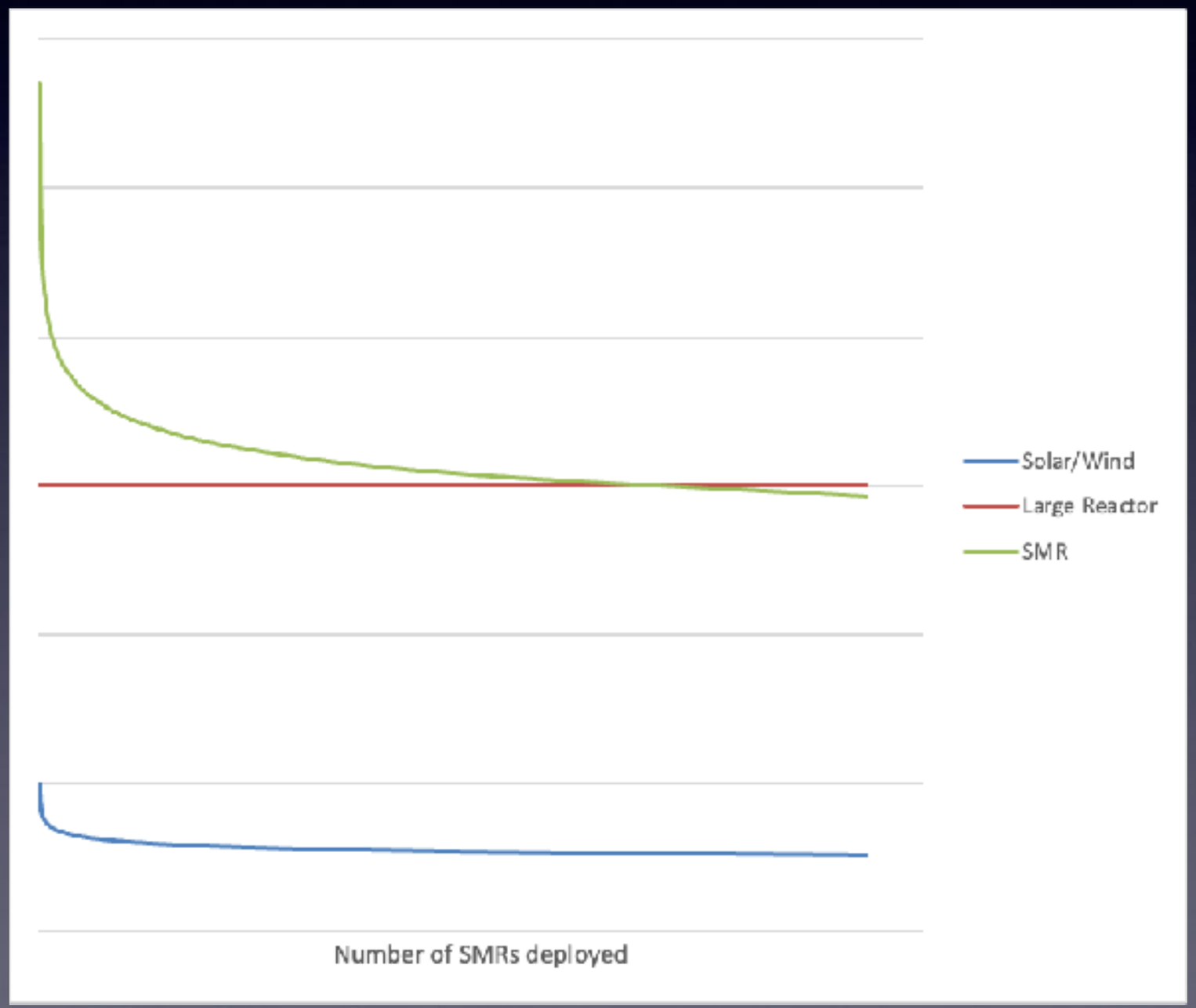
Grubler, Arnulf. 2010. "The Costs of the French Nuclear Scale-up: A Case of Negative Learning by Doing." Energy Policy 38 (9): 5174–88.

Even if there was learning, too many "loss leaders" have to be built

Learning Rate	Diseconomies of Scale Exponent 0.6	0.8
10%	700	80
5%	60,000	780

Glaser, Alexander, M.V. Ramana, Ali Ahmad, and Robert Socolow. 2015. "Small Modular Reactors: A Window on Nuclear Energy." An Energy Technology Distillate. Princeton, N.J.: Andlinger Center for Energy and the Environment at Princeton University. http://acee.princeton.edu/distillates/distillates/small-modular-reactors/.

Schematic comparison of cost of electricity generation from SMRs, large reactors, and modern renewables



The Jobs Dilemma

Source: https://s3.amazonaws.com/lowres.cartoonstock.com/food-drink-vending-snack_machine-staff_room-canteen-cake-bwhn1538_low.jpg

Will investing in SMRs create jobs?

Yes - but that is the wrong question

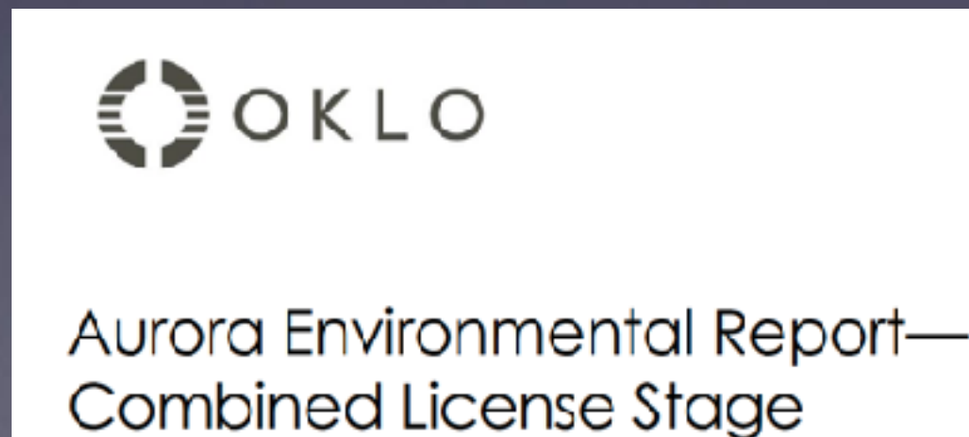
Will the number of jobs created by investing a certain amount of money in SMRs exceeds the number of jobs created by investing the same amount of money in a different low-carbon energy technology?

The Oklo Example

"expected to be installed as part of the clean energy grid in remote and off-grid communities, of populations around 1,000 or more"

"approximately 15 full-time jobs…available to local residents with a high school education… up to 40 temporary construction employees"

Source: Oklo. "Aurora Environmental Report—Combined License Stage." Rockville, MD: Nuclear Regulatory Commission, 2020. https://www.nrc.gov/docs/ML2007/ML20075A004.pdf.



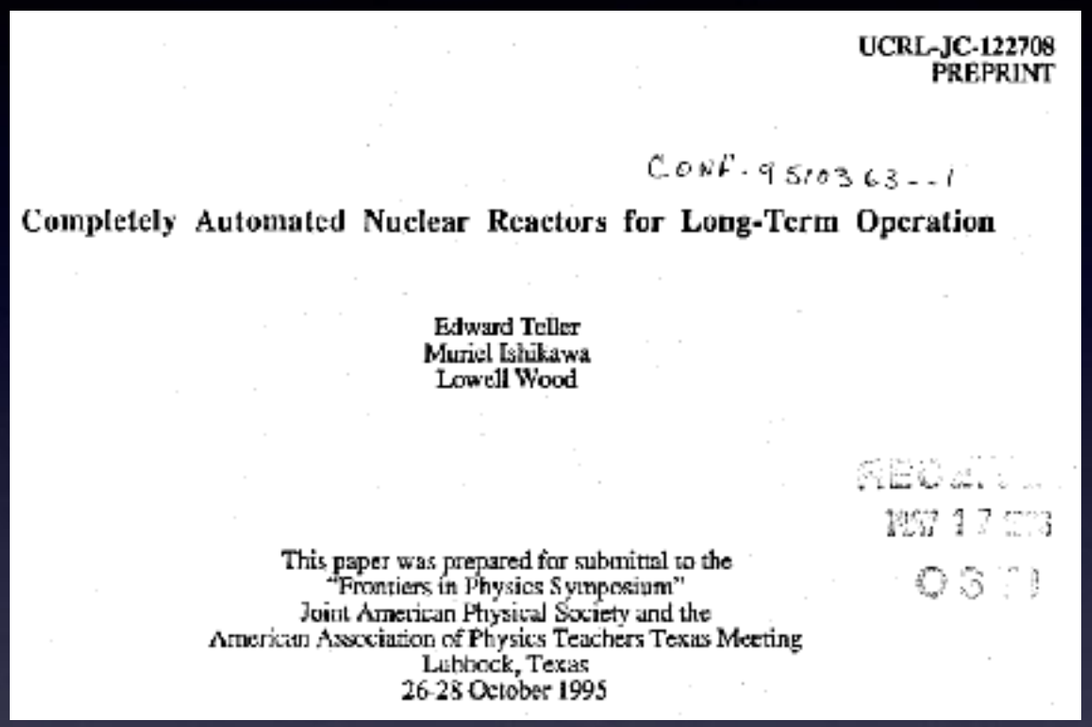
Economic Implications

1.5 MW plant => 11826 MWh at 90 percent CF

Annual pay for US nuclear power plant operators, distributors, and dispatchers = $111,220 (in 2021)

Operating labour expenses = 15 X annual pay/ energy = $141/MWh (cost of electricity assuming zero cost for building reactor and buying fuel and dealing with waste and…), which is roughly four times solar and wind

Efforts to reduce requirements for operators



UCRL-JC-122708
PREPRINT

CONF-9510363--1

Completely Automated Nuclear Reactors for Long-Term Operation

Edward Teller
Muriel Ishikawa
Lowell Wood

This paper was prepared for submittal to the
"Frontiers in Physics Symposium"
Joint American Physical Society and the
American Association of Physics Teachers Texas Meeting
Lubbock, Texas
26-28 October 1995

May 2, 2022
by POWER

ALSO IN THIS ISSUE
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History | May 2, 2022

Nuclear

Small Modular Reactors Provide Opportunity to Rethink Automation for Nuclear Generation

"in the area of operators…our (StarCore)plant will be fully automatic, and will not need any onsite. However, we are planning to have operators on the first plant, and they will be trained and certified in accordance with CNSC requirements. We will keep them at the plant until we are convinced that our automatic controls meet all of the requirements, and we can make the safety case to CNSC to take the on-site operators off."

https://www.nuclearsafety.gc.ca/eng/pdfs/Discussion-Papers/16-04/DIS-16-04-comment-received-StarCore.pdf

Lowering construction costs

The more labor which can be performed in a factory, the lower the over all costs…Factory manufacture lowers labor costs in several ways. First serial production leads to the division of labor, which in turn typically increases labor productivity. The division of labor decreases the skill set required from individual workers. Decreased labor skill sets decrease labor wage expectations. Factory work settings, as opposed to field work settings also decrease wage expectations.
Thus serial production of small reactors in factories would tend to lower labor costs of nuclear manufacture.

https://energycentral.com/c/ec/sources-nuclear-cost-saving-small-and-advanced-reactors

More jobs => more uneconomical

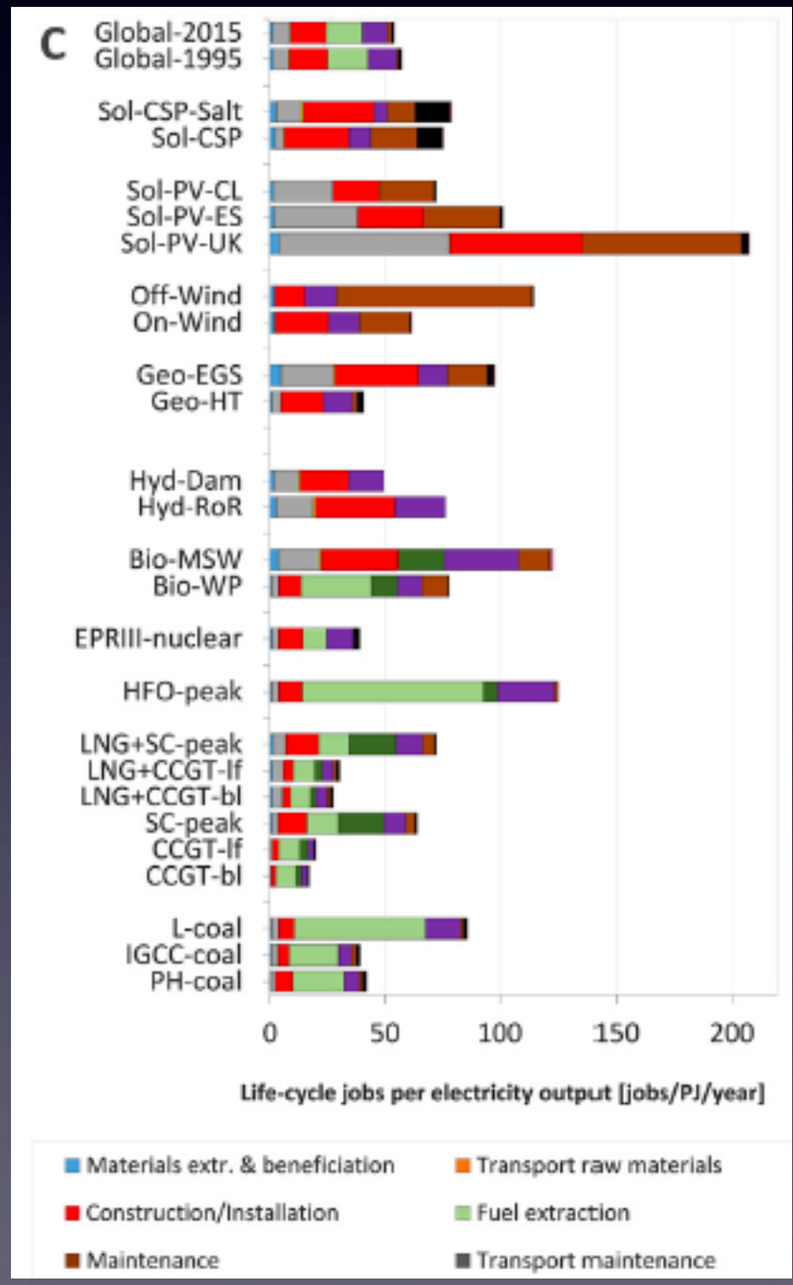
Academic Studies

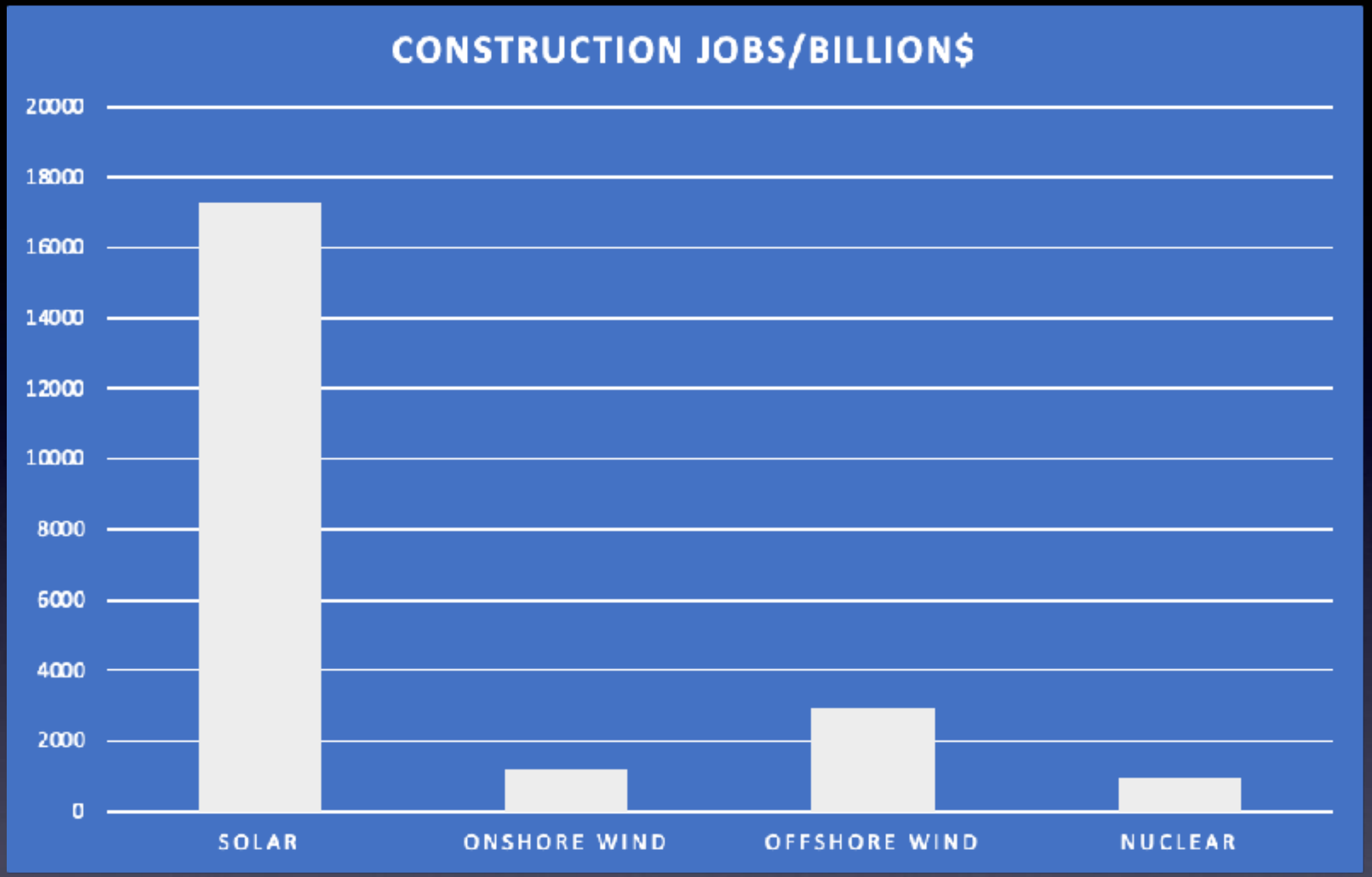
Table 2
Comparison of jobs/MWyr, jobs/MWe and jobs-years/GWh across technologies.

Workhours per year		Capacity factor (%)	Equipment lifetime (years)	Employment components			Average employment over life of facility							
							Total jobs/MWp		Total jobs/MWe		Total job-years/GWh			
Energy technology	Source of numbers			CIM (job-years/MWp)	O&M (jobs/MWp)	Fuel extraction and processing (job-years/GWh)	CIM	O&M and fuel processing	CIM	O&M and fuel processing	CIM	O&M and fuel processing	Total	Avg
Biomass 1	EPRI 2001	85	40	4.29	1.53	0.00	0.11	1.53	0.13	1.80	0.01	0.21	0.22	0.21
Biomass 2	REPP 2005	85	40	0.50	0.24	0.12	0.21	1.21	0.25	1.42	0.03	0.16	0.19	
Geothermal 1	VATA 2005	90	40	0.43	1.79	0.00	0.16	1.79	0.18	1.98	0.02	0.25	0.27	0.25
Geothermal 2	CALPIRG 2002	90	40	17.50	1.70	0.00	0.64	1.70	0.69	1.89	0.06	0.22	0.27	
Geothermal 3	EPRI 2001	90	40	4.00	1.67	0.00	0.10	1.67	0.11	1.86	0.01	0.21	0.22	
Landfill Gas 1	CALPIRG 2002	85	40	21.30	7.80	0.00	0.73	7.80	0.93	9.18	0.07	1.05	1.12	0.79
Landfill Gas 2	EPRI 2001	85	40	3.71	2.28	0.00	0.09	2.28	0.11	2.68	0.01	0.31	0.32	
Small Hydro	EPRI 2001	55	40	5.71	1.14	0.00	0.14	1.14	0.26	2.07	0.03	0.24	0.27	0.27
Solar PV 1	EPIA/Greenpeace 2008	20	25	32.00	1.00	0.00	1.68	1.08	7.60	5.08	0.84	0.57	1.42	0.87
Solar PV 2	REPP 2005	20	25	32.34	0.37	0.00	1.29	0.37	6.47	1.85	0.74	0.21	0.95	
Solar PV 3	EPRI 2001	20	25	7.14	0.12	0.00	0.29	0.12	1.43	0.60	0.16	0.07	0.23	
Solar Thermal 1	Sky Fuel/NREL 2008	40	25	10.71	1.00	0.00	0.41	1.08	1.03	2.70	0.12	0.29	0.40	0.71
Solar Thermal 2	NREL 2006	40	25	4.50	0.38	0.00	0.18	0.38	0.45	0.95	0.05	0.11	0.16	
Solar Thermal 3	EPRI 2001	40	25	5.71	0.22	0.00	0.23	0.22	0.57	0.55	0.07	0.06	0.13	
Wind 1	EWEA 2008	35	25	10.10	0.60	0.00	0.40	0.60	1.15	1.14	0.13	0.15	0.28	0.17
Wind 2	REPP 2005	35	25	3.80	0.14	0.00	0.15	0.14	0.43	0.41	0.05	0.05	0.10	
Wind 3	McKinsey 2006	35	25	10.86	0.18	0.00	0.64	0.18	1.25	0.50	0.14	0.06	0.20	
Wind 4	CALPIRG 2002	35	25	7.40	0.20	0.00	0.28	0.28	0.85	0.77	0.10	0.07	0.16	
Wind 5	EPRI 2001	35	25	2.57	0.29	0.00	0.10	0.29	0.29	0.83	0.02	0.09	0.11	
Carbon Capture & Storage	Friedmann, 2009	80	40	20.48	0.31	0.00	0.51	0.73	0.64	0.91	0.07	0.10	0.18	0.18
Nuclear	NEFF 2006	90	40	17.20	0.20	0.00	0.58	0.78	0.42	0.78	0.05	0.09	0.14	0.14
Coal	REPP 2005	80	40	8.50	0.18	0.00	0.21	0.59	0.27	0.74	0.03	0.08	0.11	0.11
Natural Gas	CALPIRG 2002	85	40	1.62	0.10	0.00	0.03	0.77	0.03	0.91	0.00	0.10	0.11	0.11
Energy Efficiency 1	ACEEE 2008	100	20										0.17	0.33
Energy Efficiency 2	Goldemberg, 2009	100	20										0.50	

Wei, Max, Shana Patadia, and Daniel M. Kammen. "Putting Renewables and Energy Efficiency to Work: How Many Jobs Can the Clean Energy Industry Generate in the US?" Energy Policy 38, no. 2 (February 1, 2010): 919–31. https://doi.org/10.1016/j.enpol.2009.10.044.

Kis, Zoltán, Nikul Pandya, and Rembrandt H. E. M. Koppelaar. "Electricity Generation Technologies: Comparison of Materials Use, Energy Return on Investment, Jobs Creation and CO2 Emissions Reduction." Energy Policy 120 (September 1, 2018): 144–57. https://doi.org/10.1016/j.enpol.2018.05.033.





My calculations based on Pai, Sandeep, Johannes Emmerling, Laurent Drouet, Hisham Zerriffi, and Jessica Jewell. "Meeting Well-below 2°C Target Would Increase Energy Sector Jobs Globally." *One Earth* 4, no. 7 (July 23, 2021): 1026–36. https://doi.org/10.1016/j.oneear.2021.06.005. and"Lazard's Levelized Cost of Energy-Version 15.0." New York: Lazard, October 2021. https://www.lazard.com/perspective/levelized-cost-of-energy-levelized-cost-of-storage-and-levelized-cost-of-hydrogen/.

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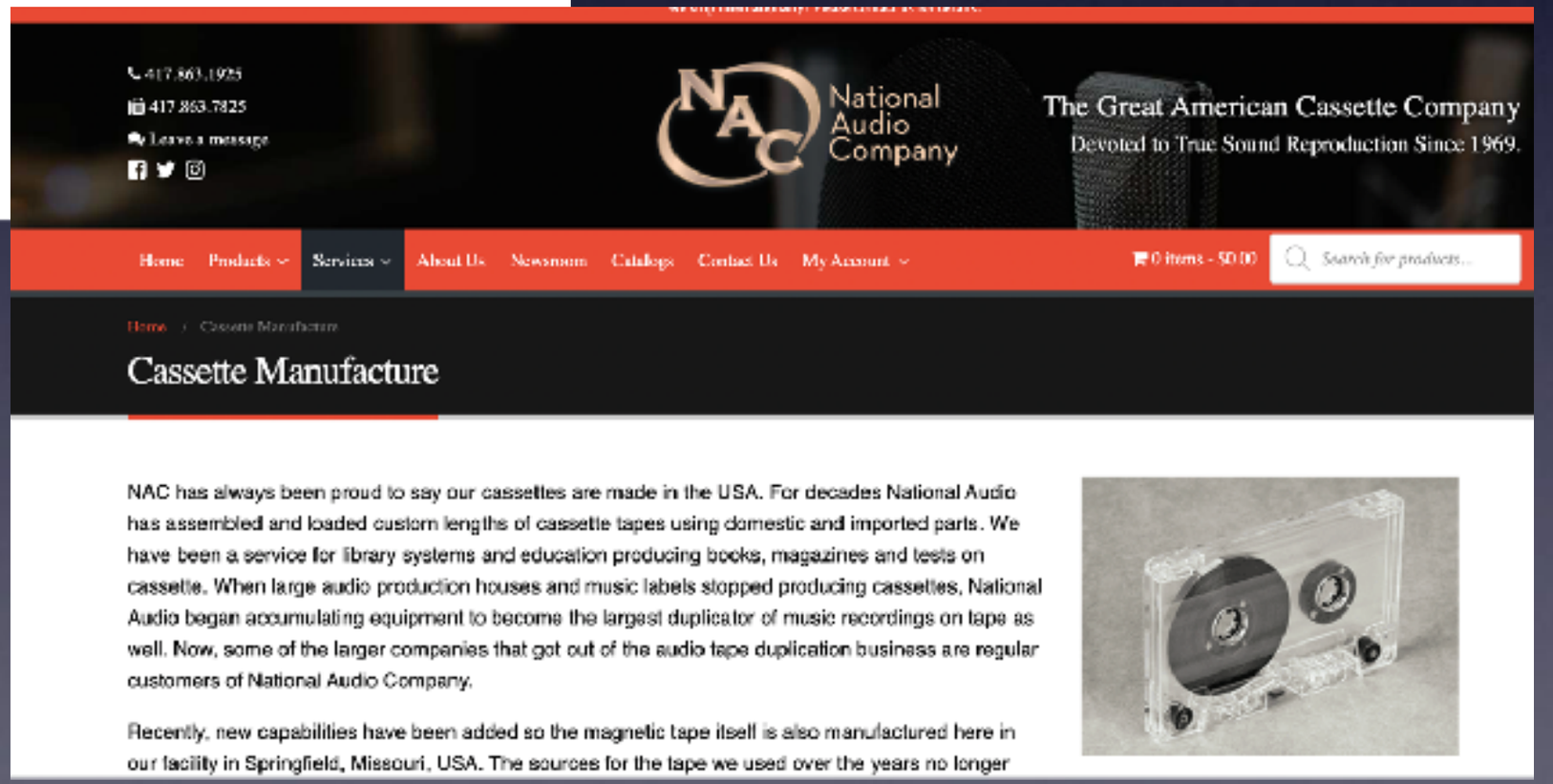

Conclusion

Nuclear energy facing severe economic challenges

Priority for industry is reducing jobs

Nuclear jobs - more geographically concentrated and high paying => more political power