The World Nuclear Industry Status Report 2021 (WNISR2021) - *Plus Updates!*

www.WorldNuclearReport.org

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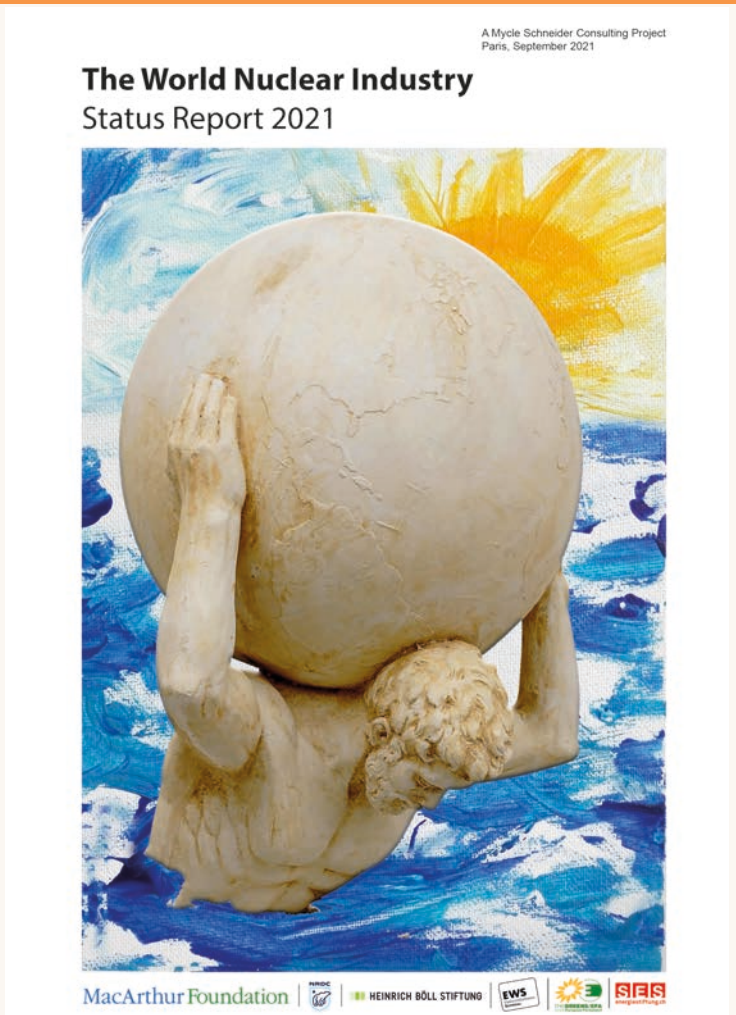
International Analyst on Energy and Nuclear Policy, Paris
Coordinator and Publisher of the WNISR

Presentation at the
XXXVI Conferència Catalana Per Un Futur Sense Nuclears I Energèticament Sostenible 2022
Barcelona, 3 May 2022

International, Interdisciplinary Team for a Multi-Indicator Analysis



The World Nuclear Industry
Status Report 2021

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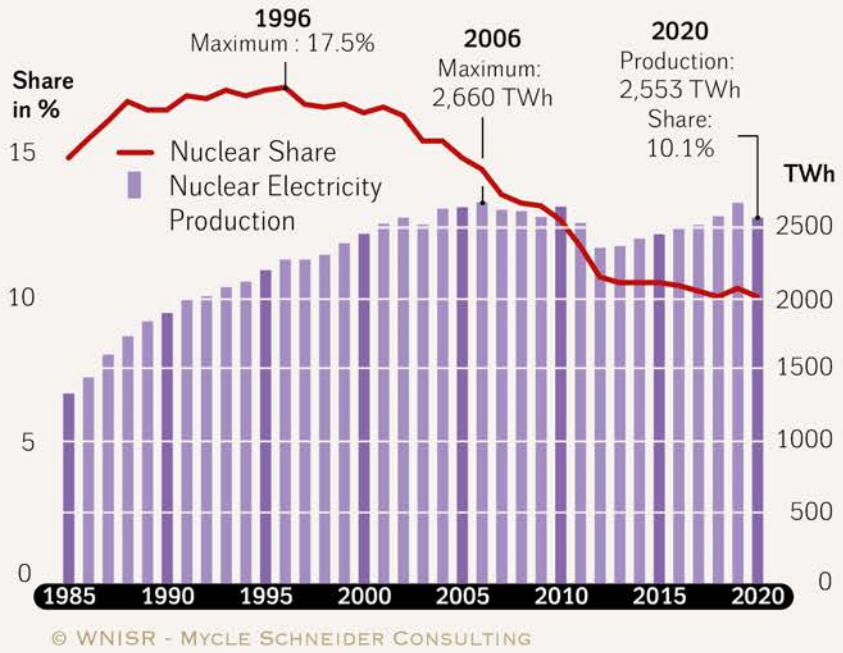
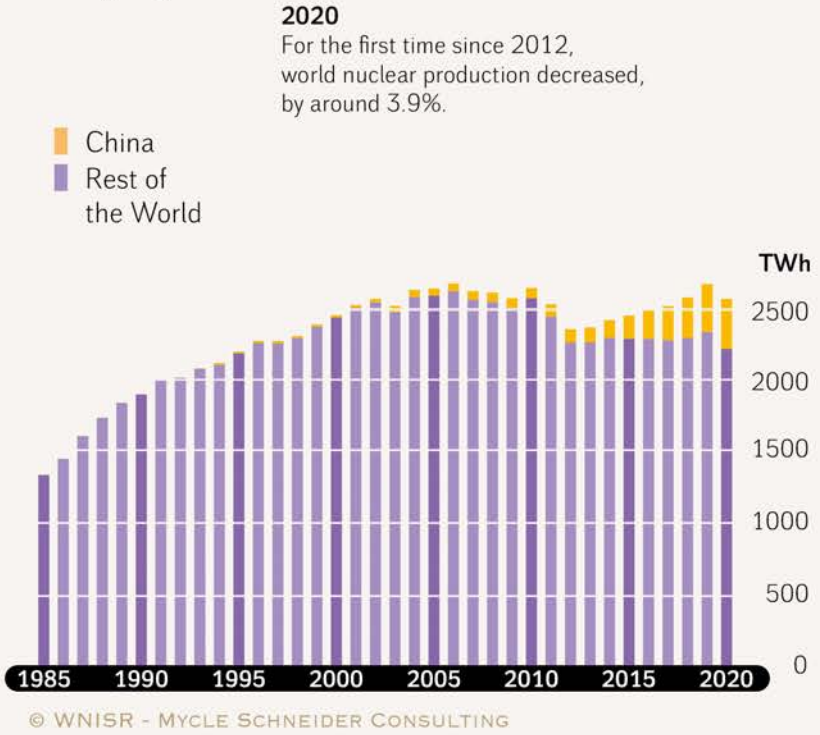
Nuclear Electricity Production 1985–2020 in the World...

in TWh (net) and Share in Electricity Generation (gross)



...and in China and the Rest of the World

in TWh (net)



Sources: WNISR, with BP, IAEA-PRIS, 2021

Nuclear Electricity Production 1985–2020 in the World...

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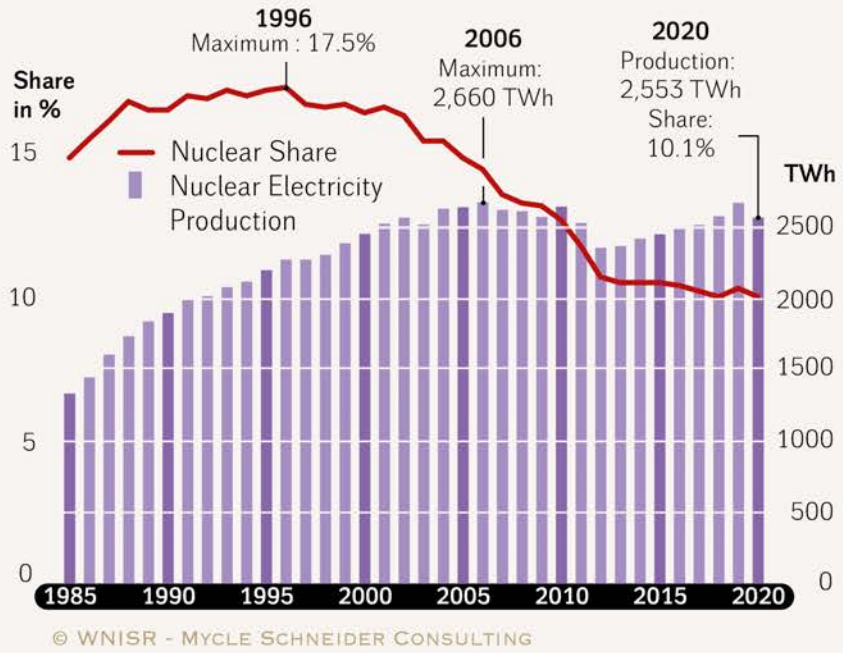

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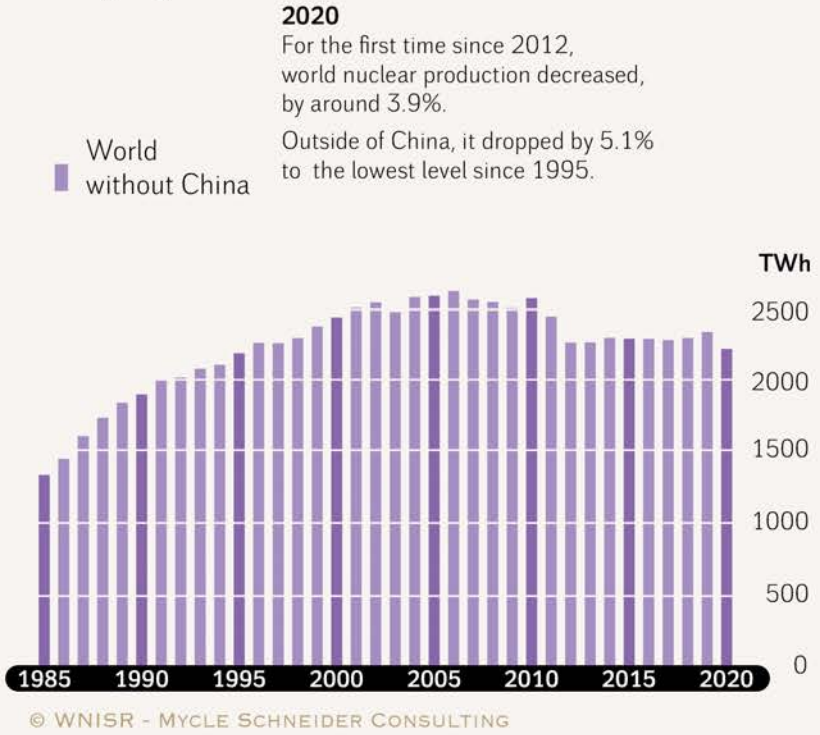


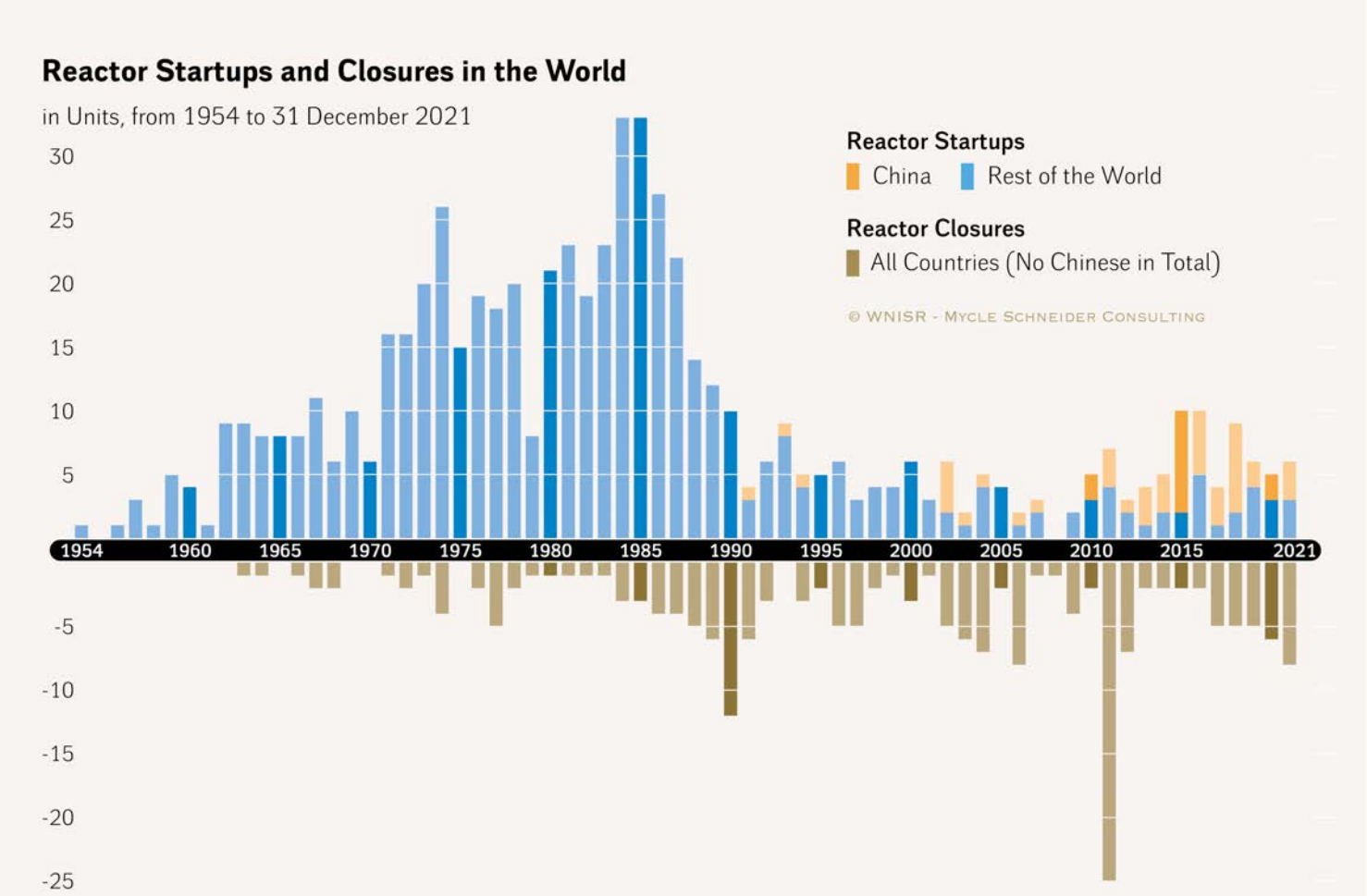
Sources: WNISR, with BP, IAEA-PRIS, 2021

Nuclear Production in 2019-2020 and Historic Maximum

in TWh and
% of Electricity Production

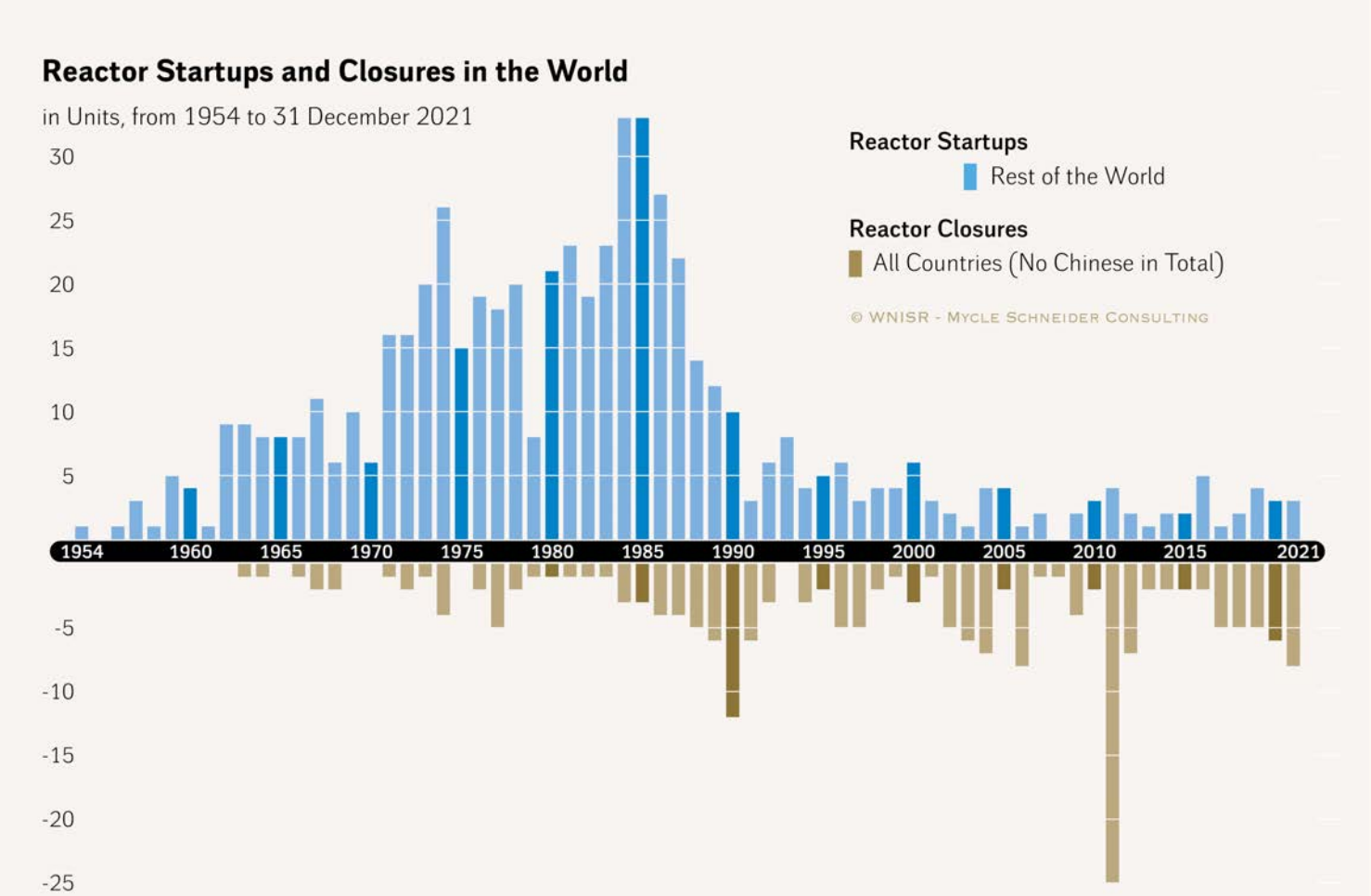
Sources: WNISR, with IAEA-PRIS, RTE and SFOE, 2021

GLOBAL OVERVIEW – STARTUPS AND CLOSURES

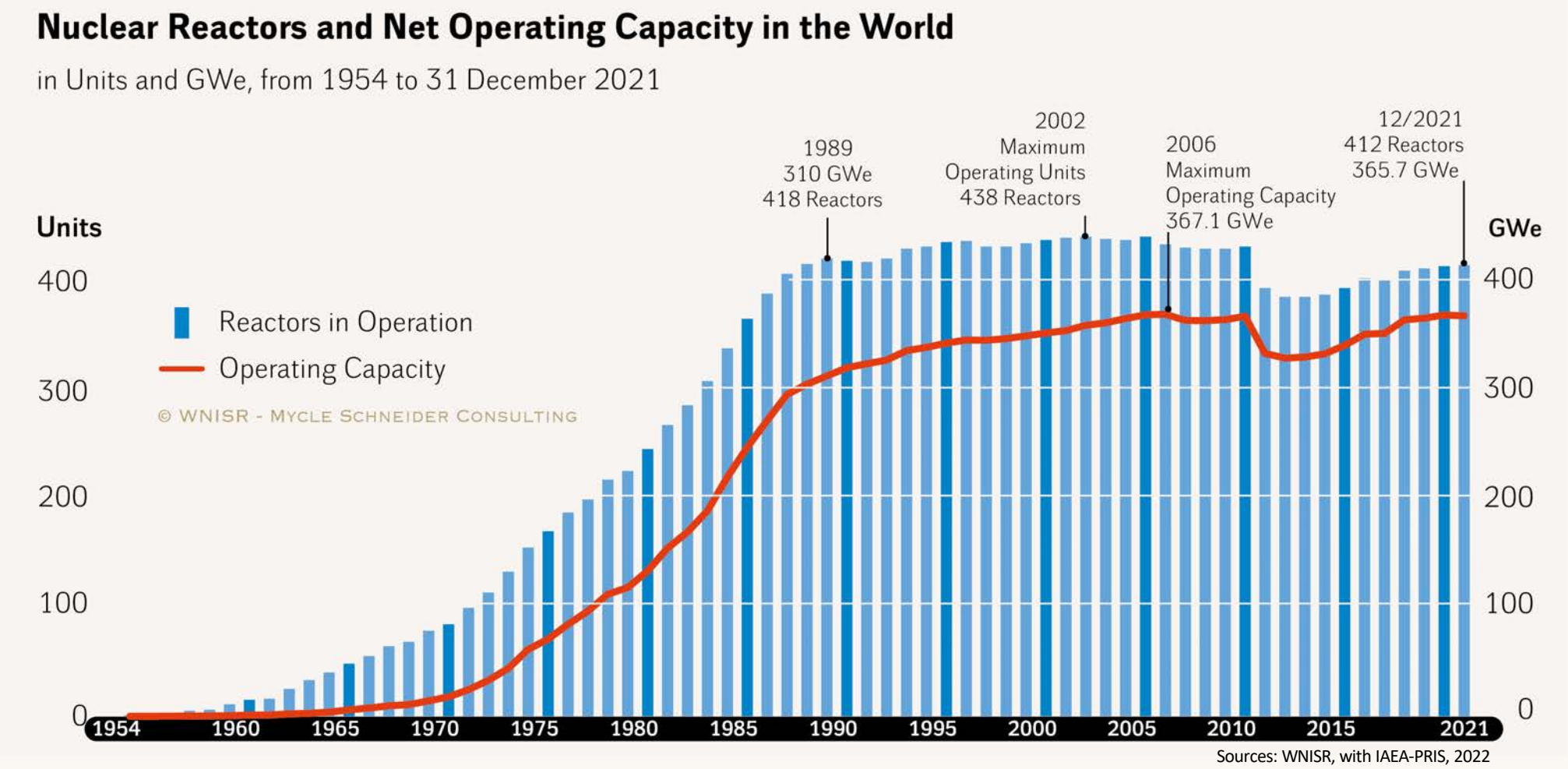


Sources: WNISR, with IAEA-PRIS, 2022

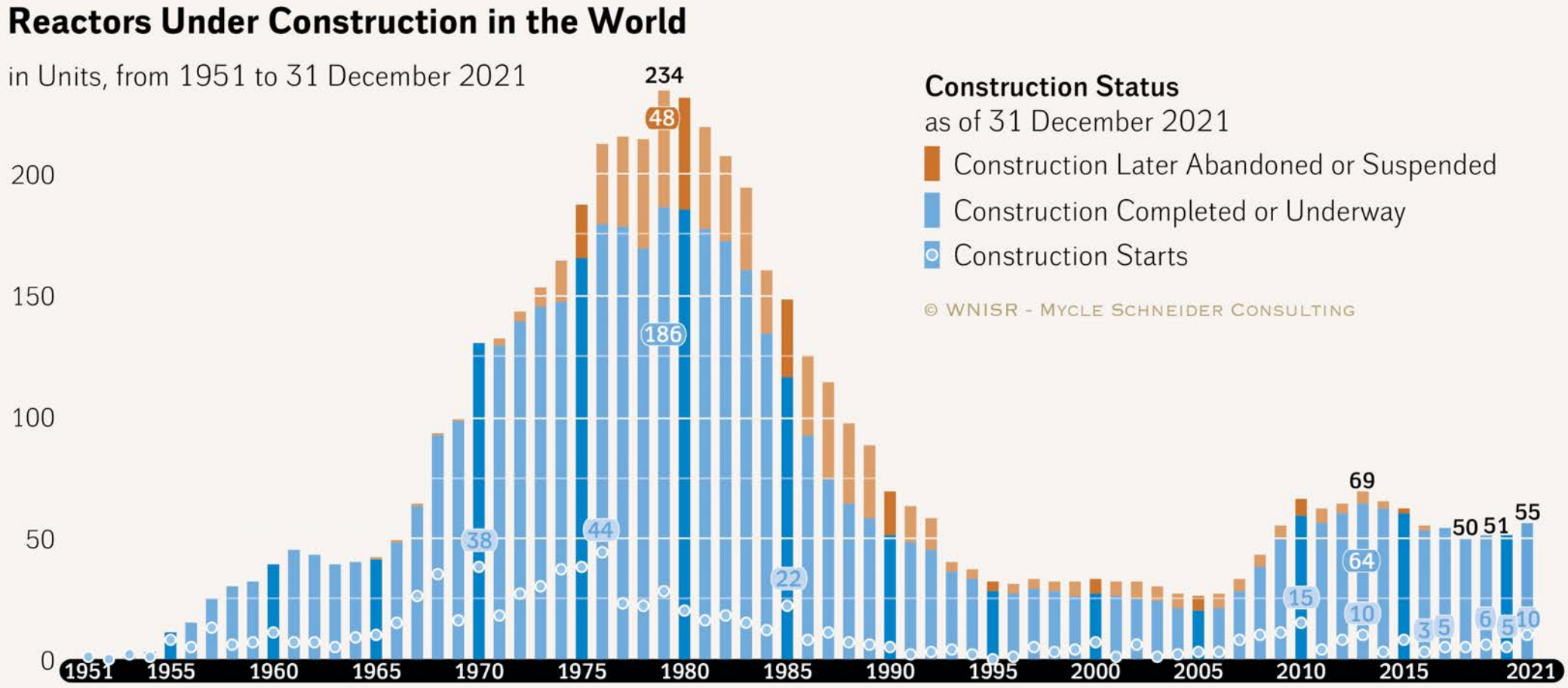
GLOBAL OVERVIEW – STARTUPS AND CLOSURES



Sources: WNISR, with IAEA-PRIS, 2022



Sources: WNISR, with IAEA-PRIS, 2022



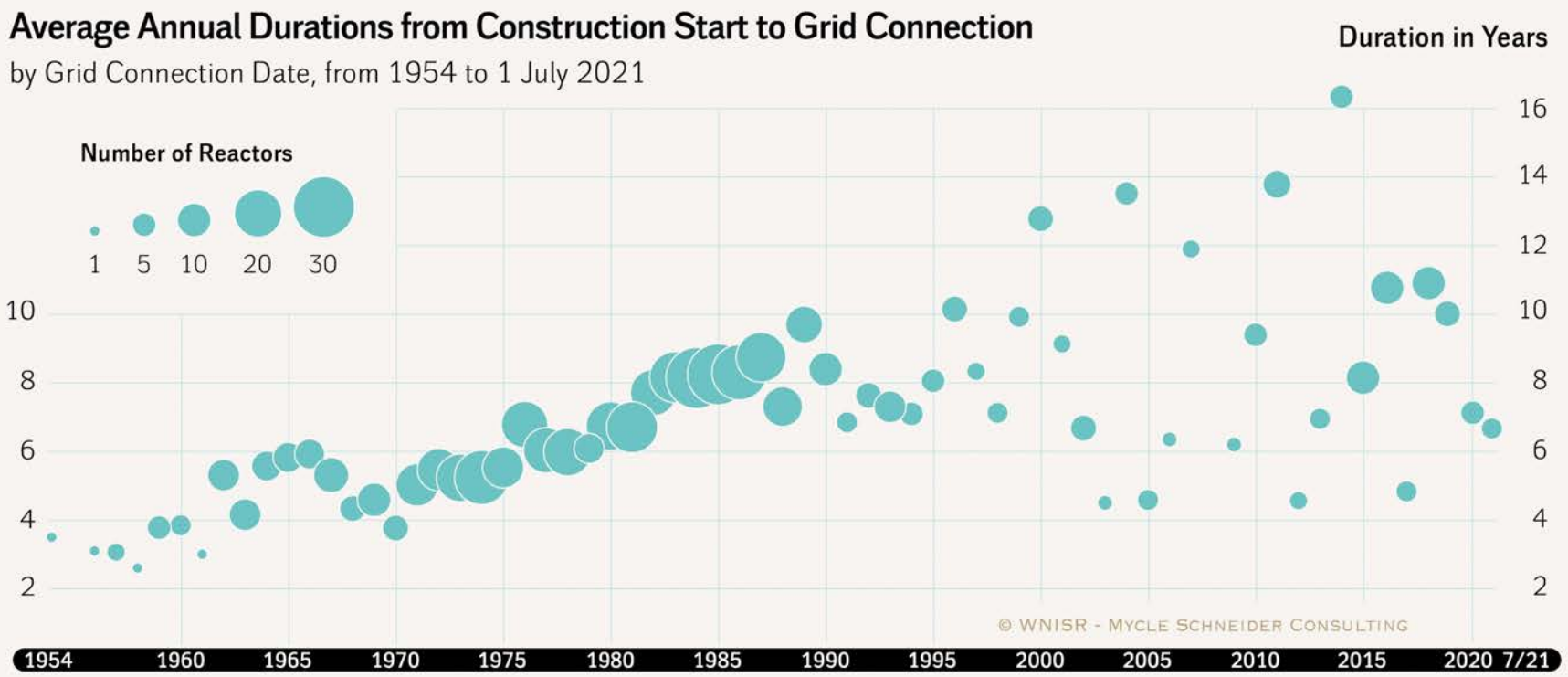
Sources: WNISR, with IAEA-PRIS, 2022

Nuclear Reactors "Under Construction" (as of 31 December 2021)

Country	Units	Capacity (MW net)	Construction Start	Grid Connection	Units Behind Schedule
China	20	19 204	2012 – 2021	2022 – 2027	4
India	8	6 194	2004 – 2021	2022 – 2026	6
South Korea	4	5 360	2012 – 2018	2022 – 2025	4
Russia	3	2 650	2018 – 2021	2022 – 2026	0
Turkey	3	3 342	2018 – 2021	2024 – 2026	1
Bangladesh	2	2 160	2017 – 2018	2023 – 2024	0
Slovakia	2	880	1985	2022 – 2023	2
UAE	2	2 690	2014 – 2015	2022 – 2023	2
UK	2	3 260	2018 – 2019	2026 – 2027	2
USA	2	2 234	2013	2022 – 2023	2
Argentina	1	25	2014	2024	1
Belarus	1	1 110	2014	2022	1
Finland	1	1 600	2005	2022	1
France	1	1 600	2007	2023	1
Iran	1	1 196	1976	2024	1
Japan	1	1 325	2007	2025	1
Pakistan	1	1 014	2016	2022	1
Total	**55**	**55 844**	**1976 - 2021**	**2022 – 2027**	**30**

Sources: WNISR, with IAEA-PRIS, 2022

GENERAL OVERVIEW — CONSTRUCTION TIMES 1



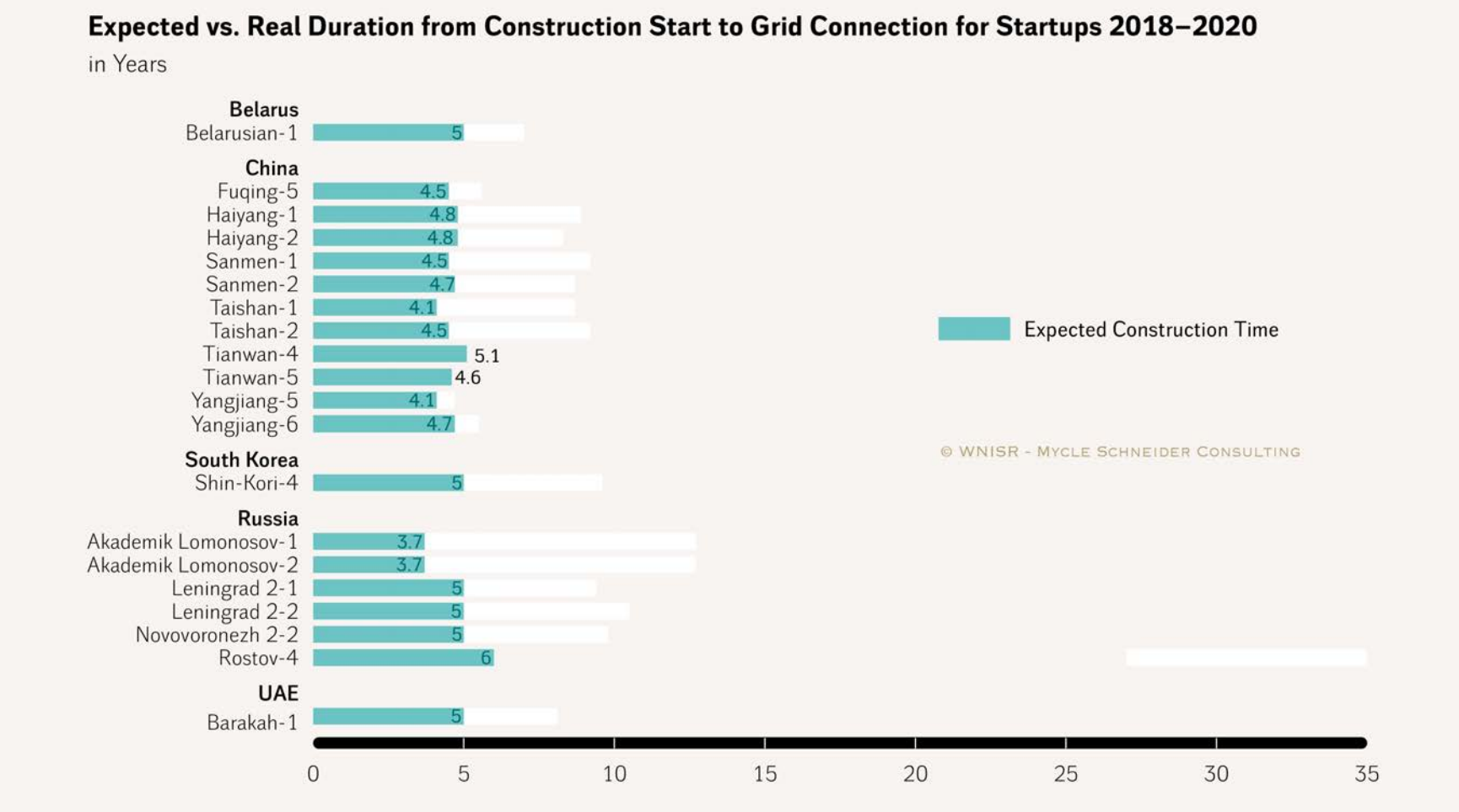
Sources: WNISR, with IAEA-PRIS, 2021

Duration from Construction Start to Grid Connection

Construction Times of 63 Units Started-up 2011–2020				
Country	Units	Construction Time (in Years)		
		Mean Time	Minimum	Maximum
China	37	6.1	4.1	11.2
Russia	10	18.7	8.1	35.1
South Korea	5	6.4	4.2	9.6
India	3	11.5	8.7	14.2
Pakistan	3	5.4	5.2	5.6
Argentina	1	33.0	33.0	
Belarus	1	7.0	7.0	
Iran	1	36.3	36.3	
UAE	1	8.1	8.1	
USA	1	42.8	42.8	
World	63	9.9	4.1	42.8

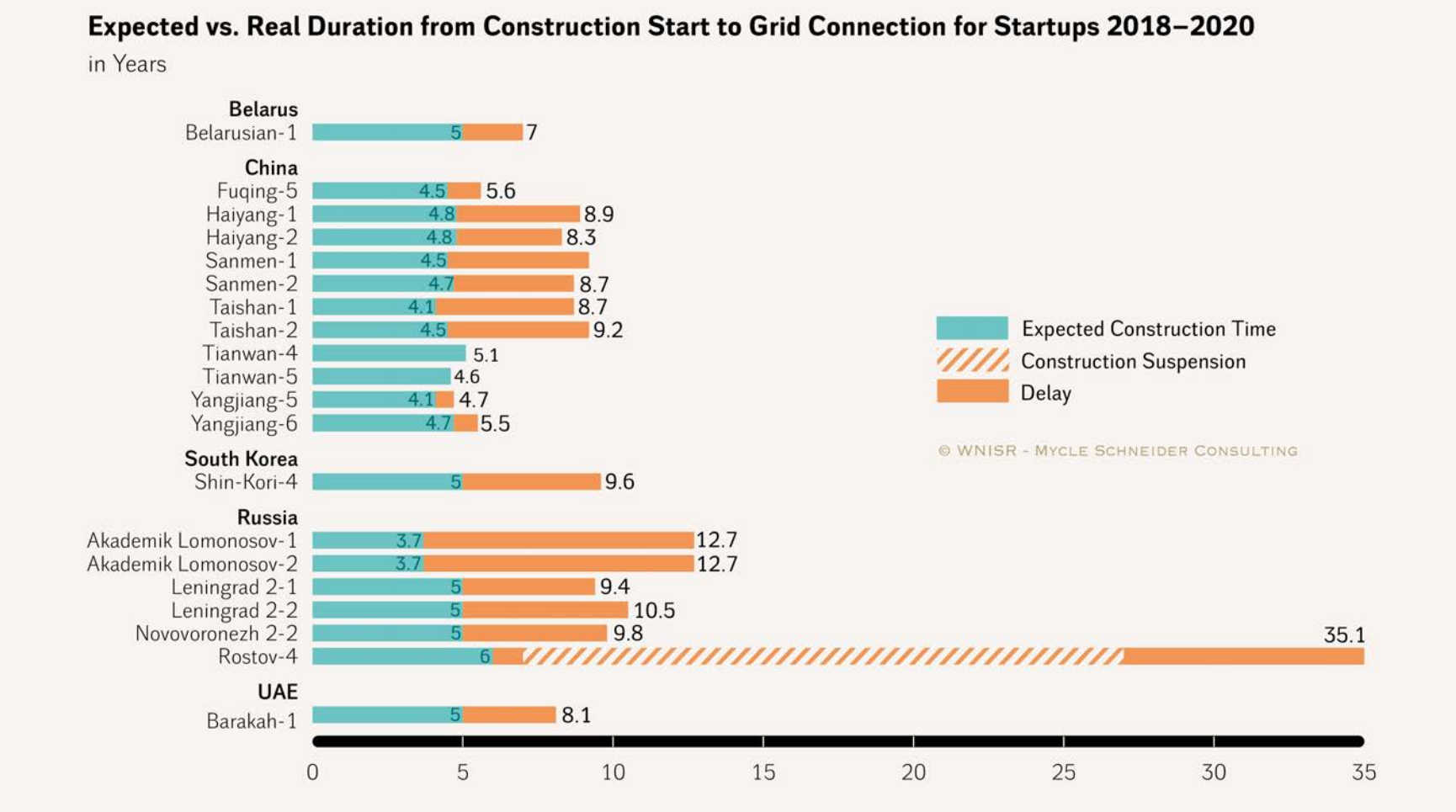
Sources: WNISR, with IAEA-PRIS, 2021

GENERAL OVERVIEW — CONSTRUCTIONS



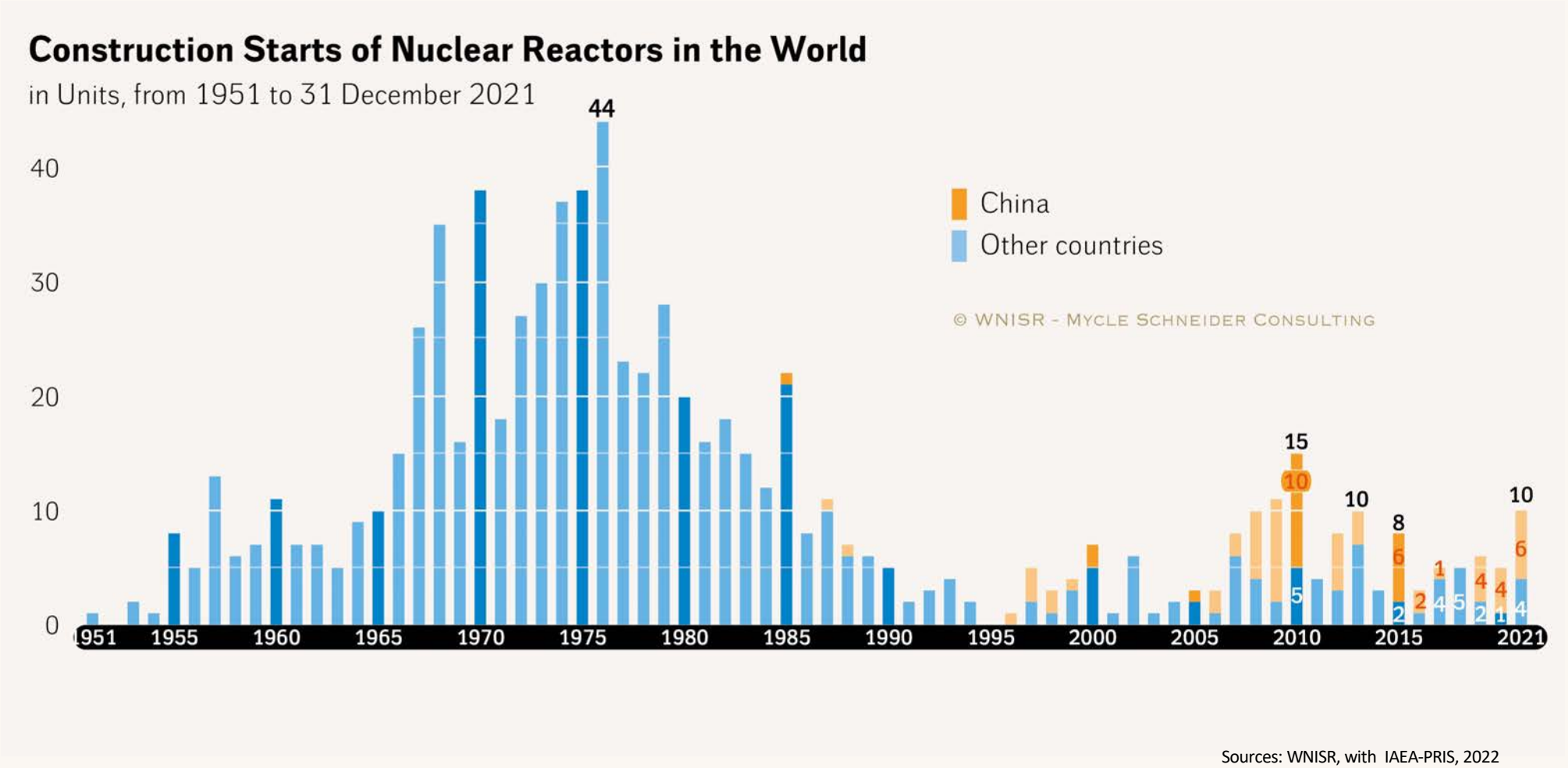
Sources: WNISR, with IAEA-PRIS, 2021

GENERAL OVERVIEW — CONSTRUCTIONS & DELAYS



Sources: WNISR, with IAEA-PRIS, 2021

GLOBAL OVERVIEW – CONSTRUCTIONS



Sources: WNISR, with IAEA-PRIS, 2022

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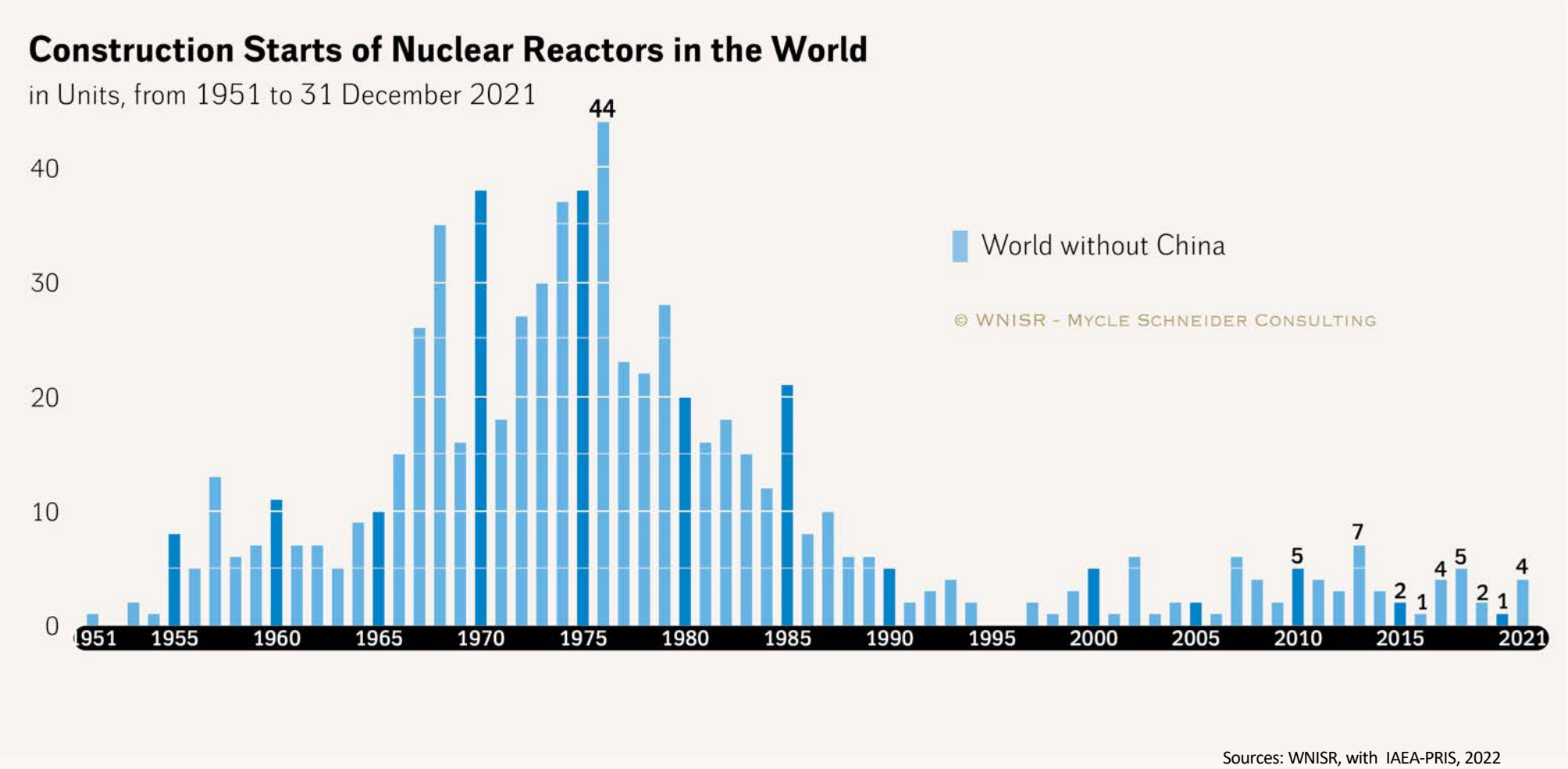
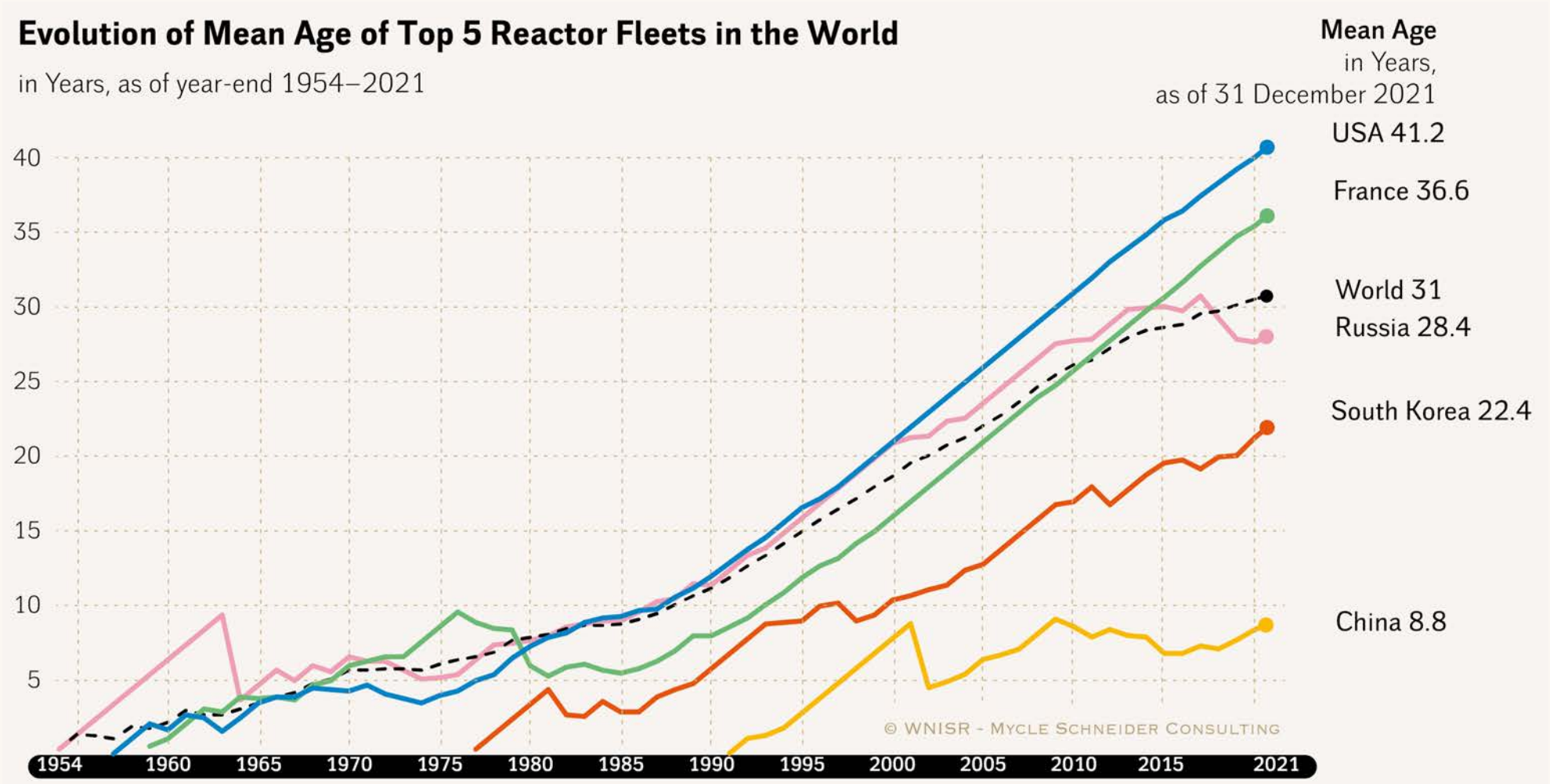
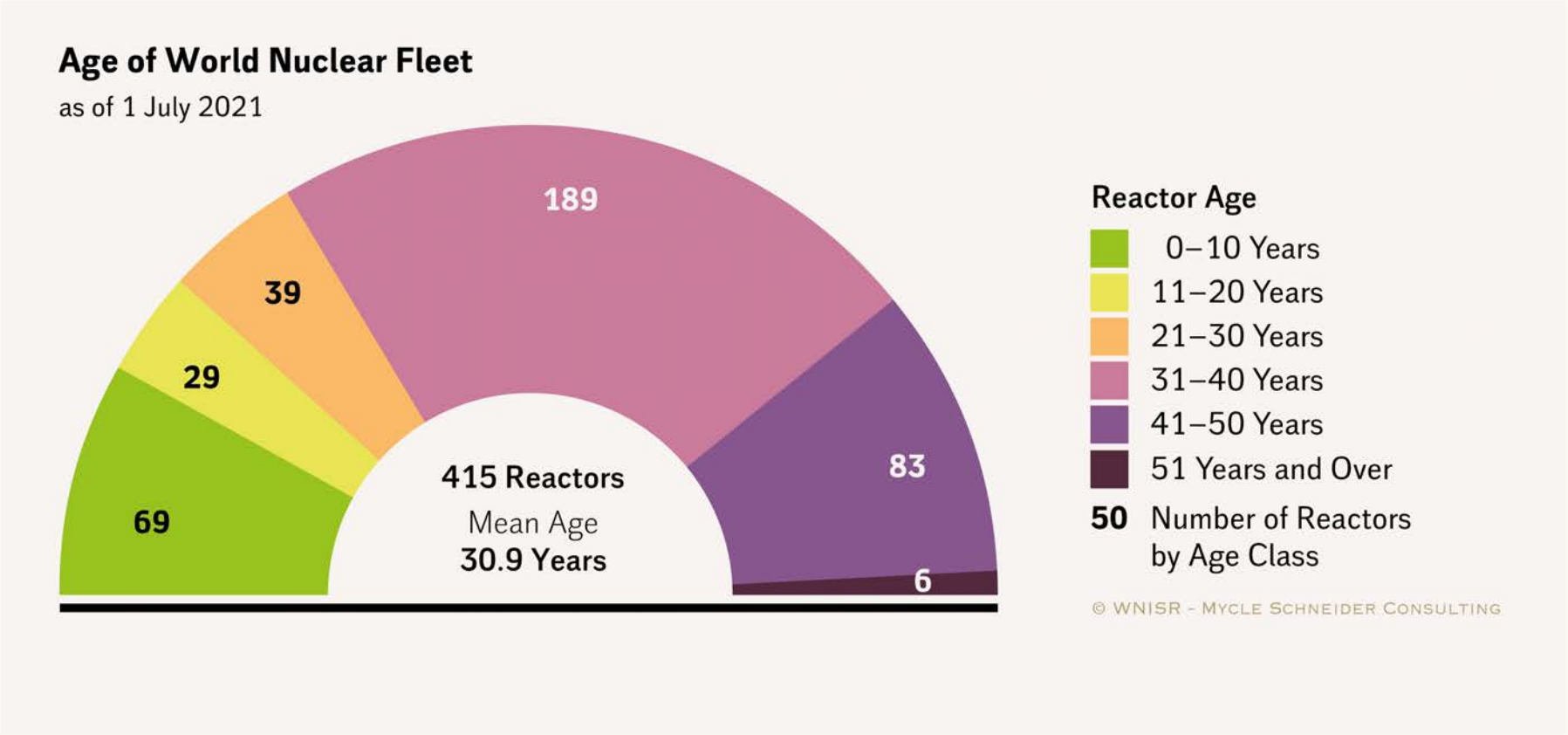


Sources: WNISR, with IAEA-PRIS, 2022

GENERAL OVERVIEW — AGE EVOLUTION OF TOP 5 REACTOR FLEETS

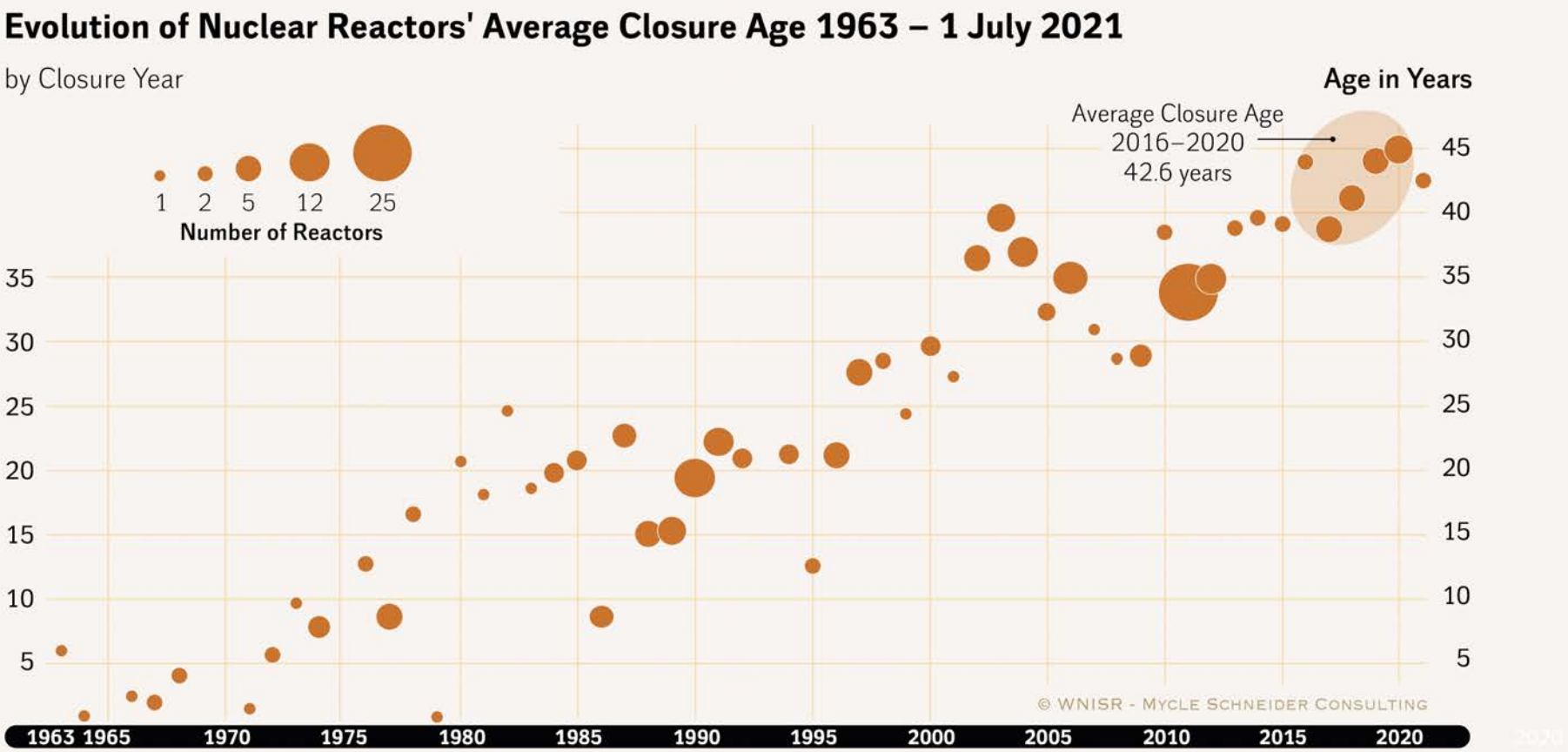


WORLD FLEET - OPERATING AGE: 2/3 ARE 31 YEARS AND OLDER



Sources: WNISR, with IAEA-PRIS, 2021

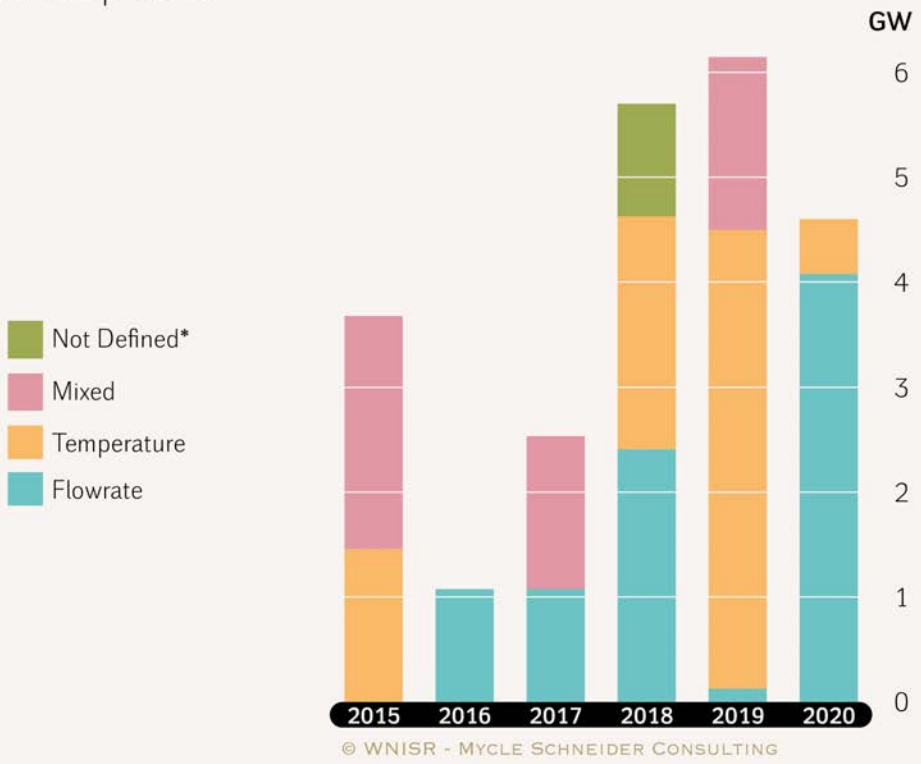
WORLD FLEET – CLOSED REACTORS AGE



Sources: WNISR, with IAEA-PRIS, 2021

Climate Related Unavailabilities of French Nuclear Power Plants 2015–2020
Maximum Simultaneous Unavailable Capacity

in GW per Year per Cause



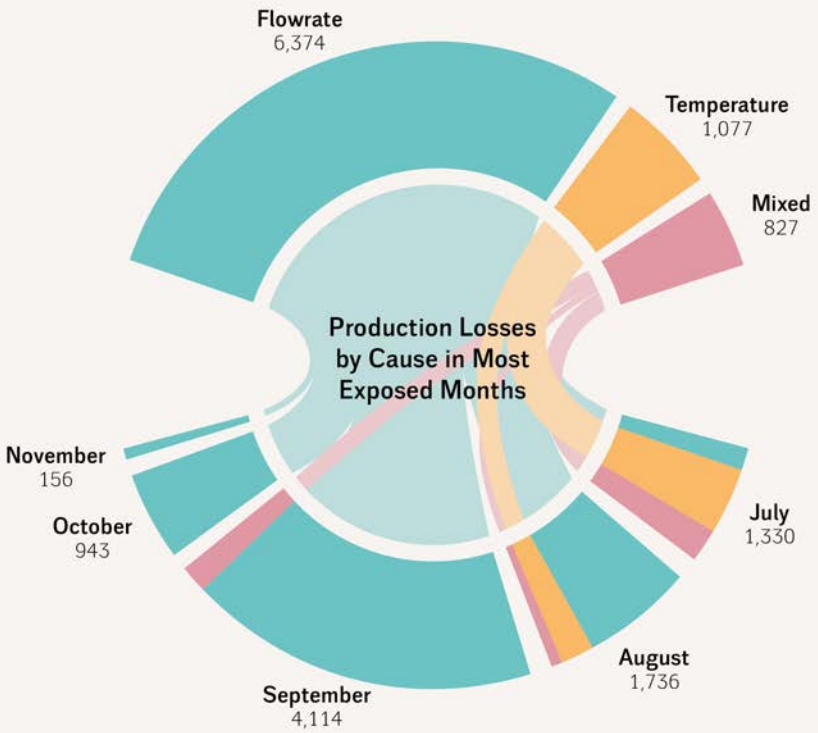
Sources: RTE and Callendar, 2021

Weather-related disruptions of nuclear power production in France since 2015:

- **357 outages** identified
- At least a few dozen disruptions a year
- Up to **2,300 reactor-hours** lost in a year
- Up to **6.2 GW** unavailable

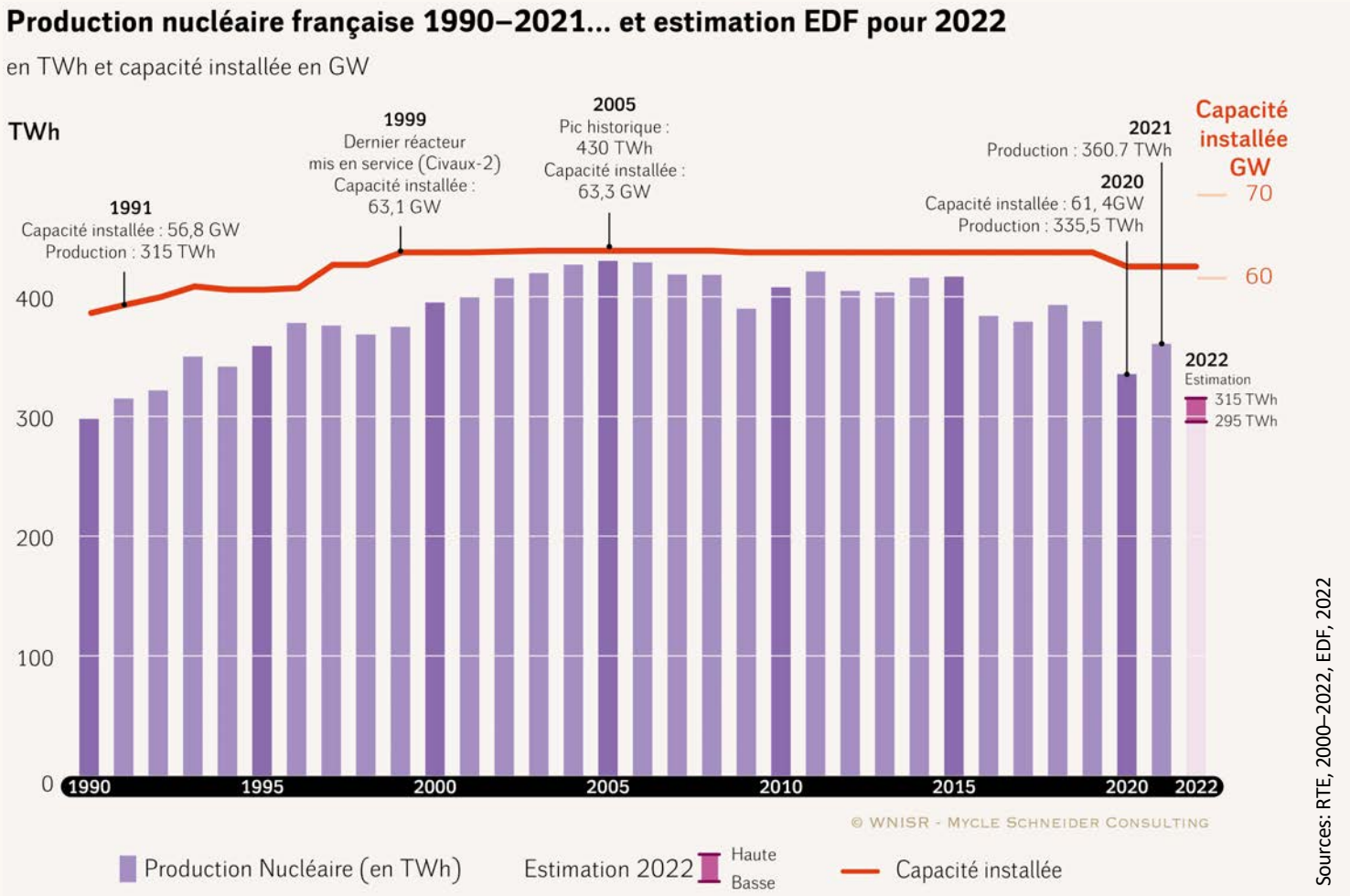
Climate Related Unavailabilities of French Nuclear Power Plants 2015–2020

in GWh by Most Probable Cause and Month



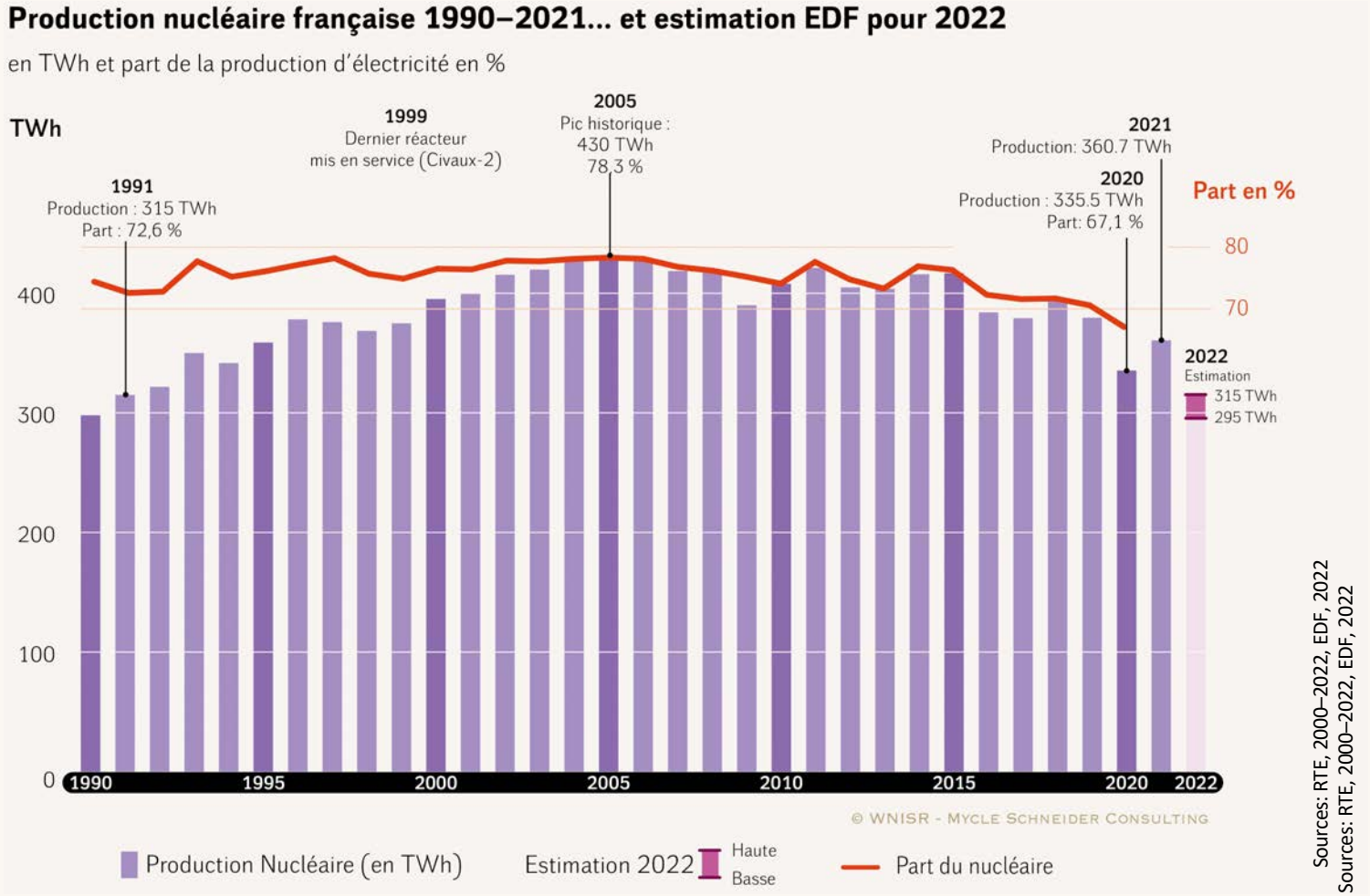
Sources: REMIT, compiled by Callendar 2021

FRANCE FOCUS — UNPRECEDENTED DROP IN NUCLEAR POWER GENERATION



Sources: RTE, 2000–2022, EDF, 2022

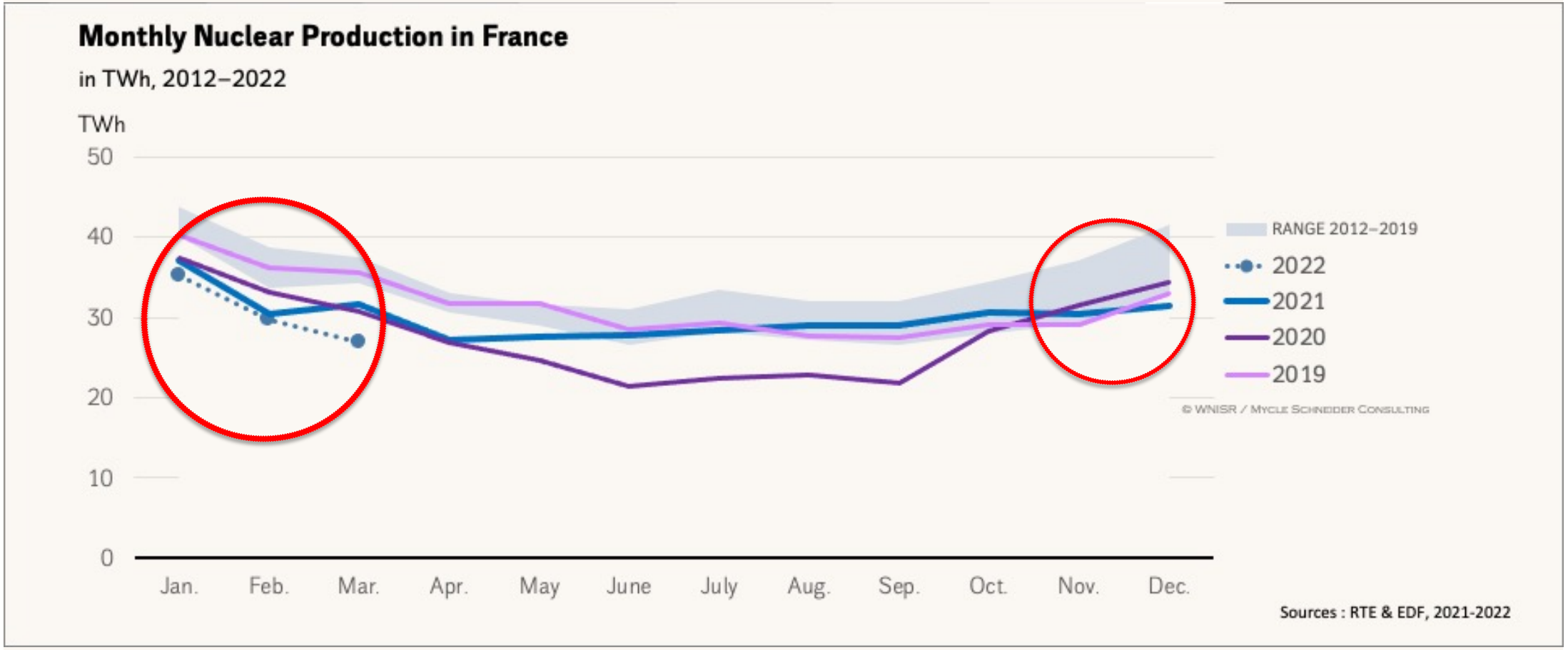
FRANCE FOCUS — UNPRECEDENTED DROP IN NUCLEAR POWER GENERATION



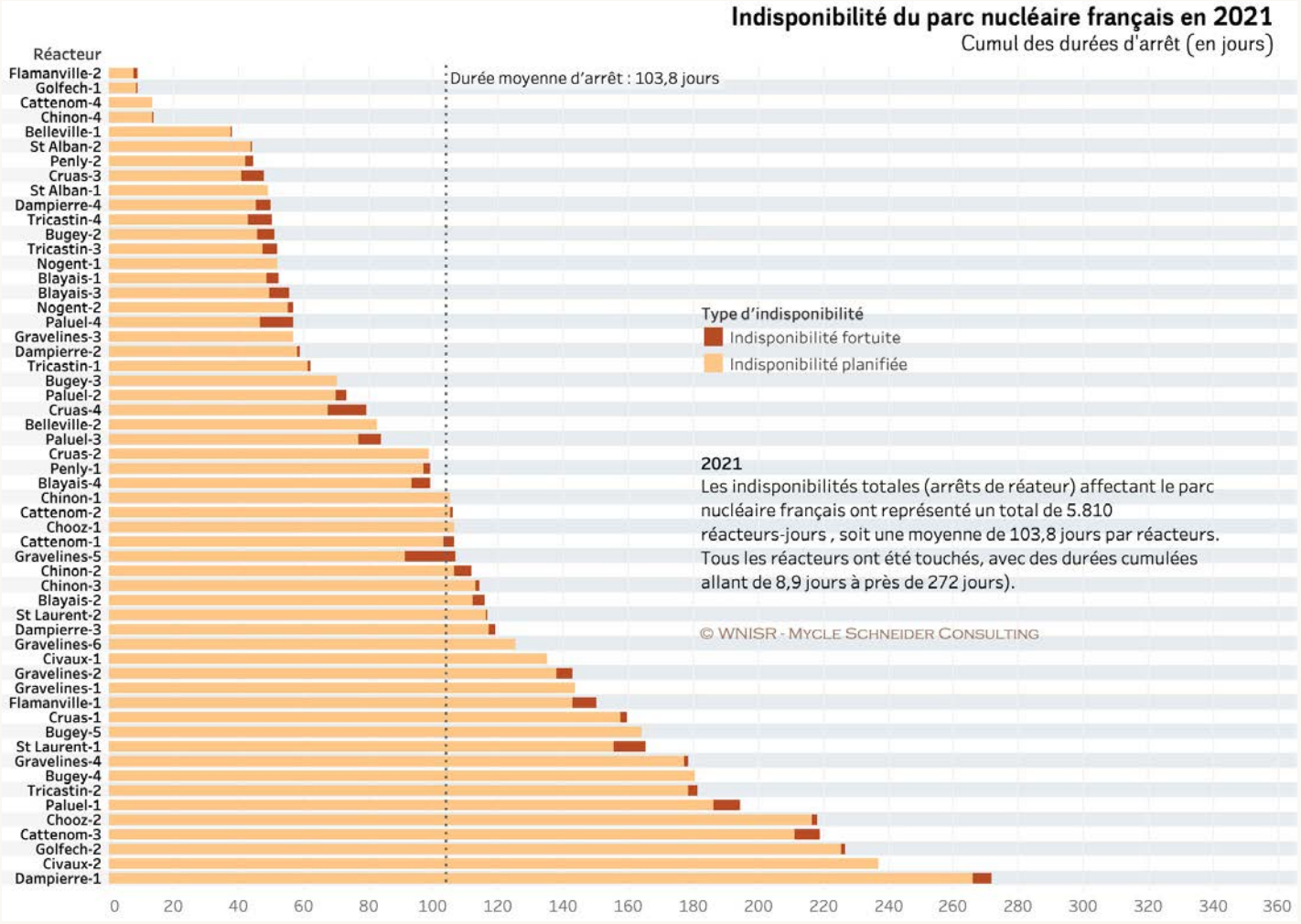
Sources: RTE, 2000–2022, EDF, 2022

Sources: RTE, 2000–2022, EDF, 2022

FRANCE FOCUS — MONTHLY NUCLEAR PRODUCTION IN FRANCE

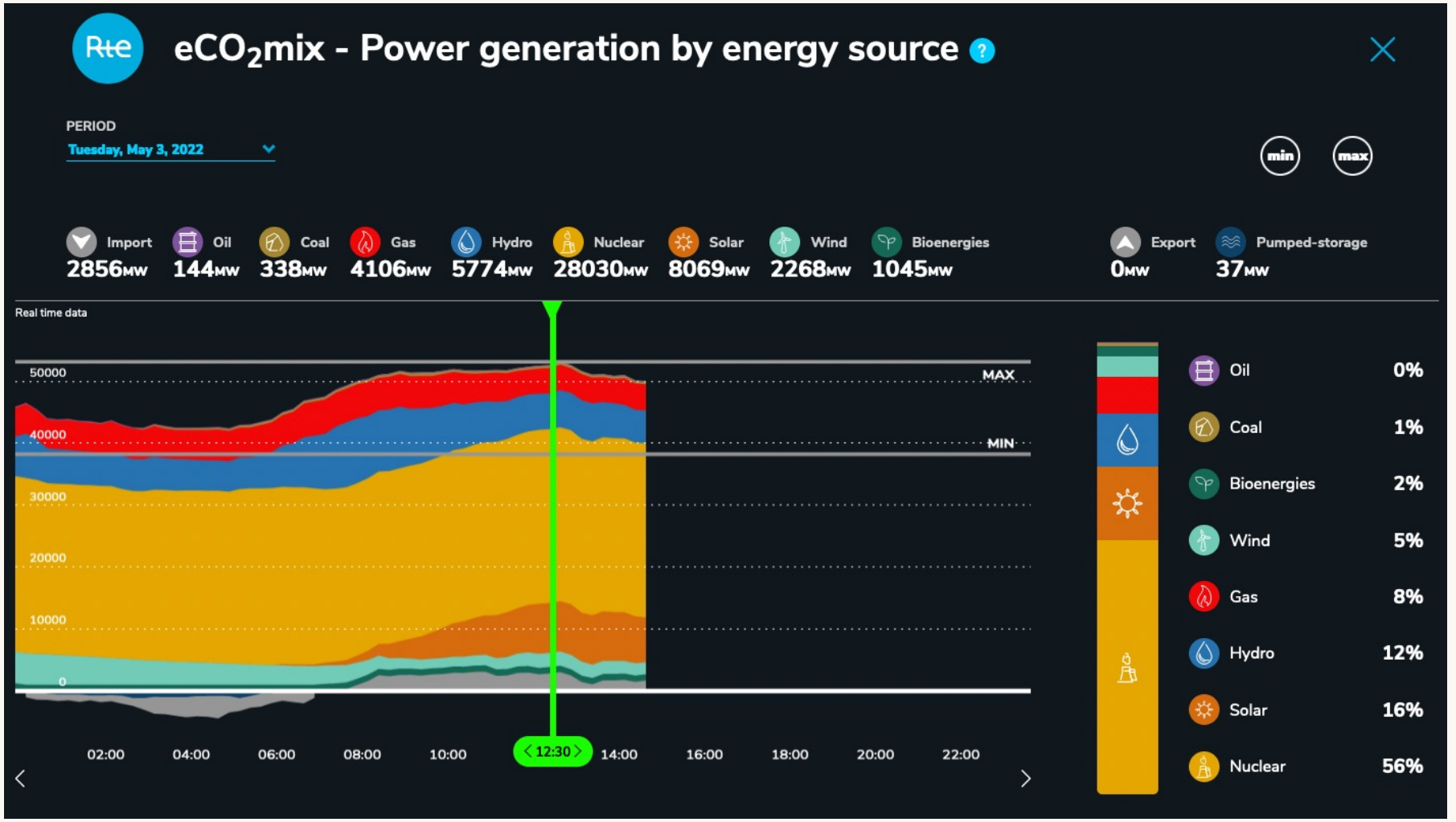


FRANCE FOCUS — NUCLEAR PLANTS INCREASINGLY UNRELIABLE



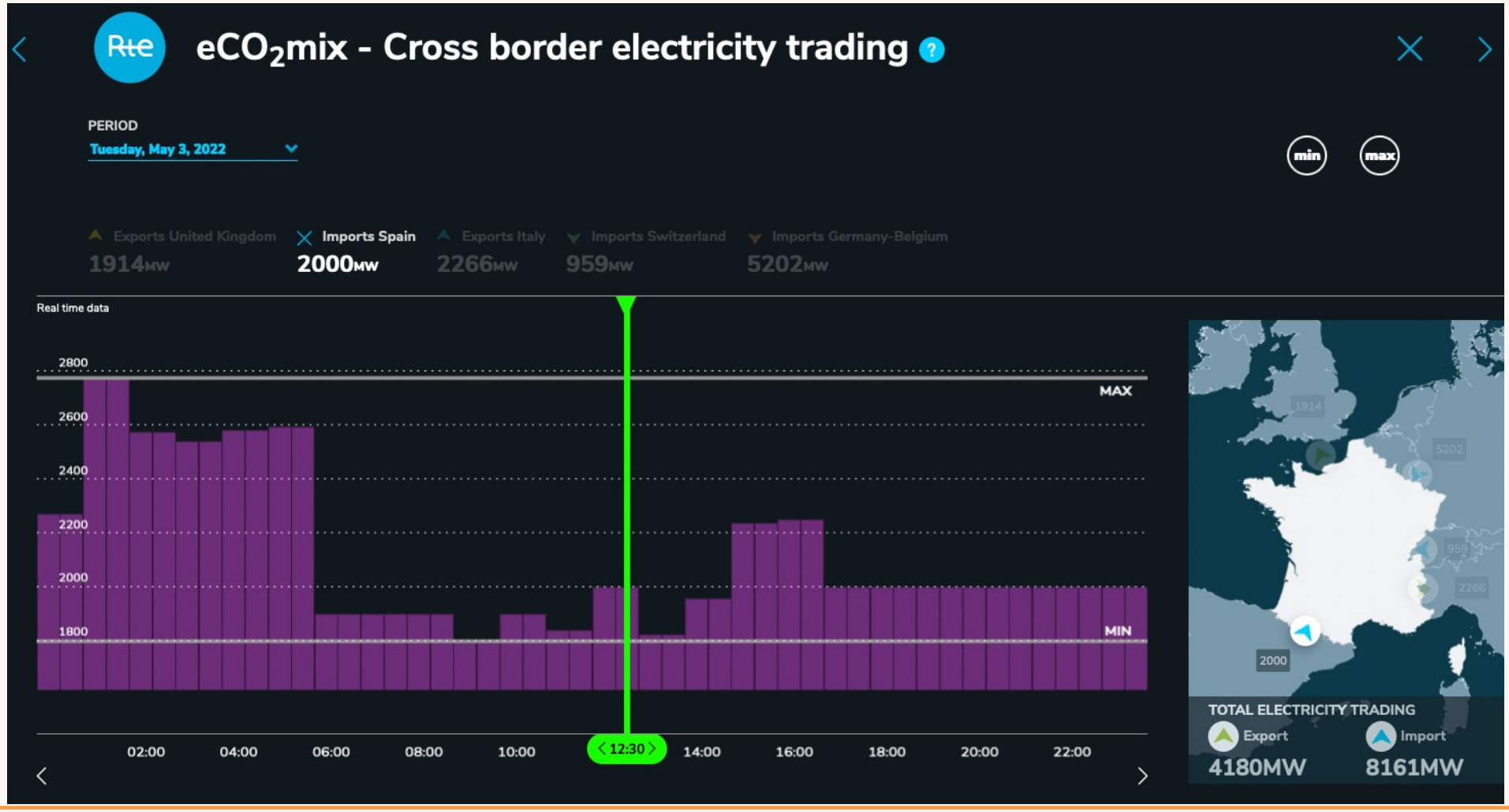
Sources: RTE and EDF, 2022

FRANCE FOCUS – 3 May 2022, 12h30 < 46% OF NUCLEAR CAPACITY OPERATING



Source: https://www.rte-france.com/en/eco2mix/power-generation-energy-source

FRANCE FOCUS – 3 May 2022, 12h30, Import from Spain 2 GW

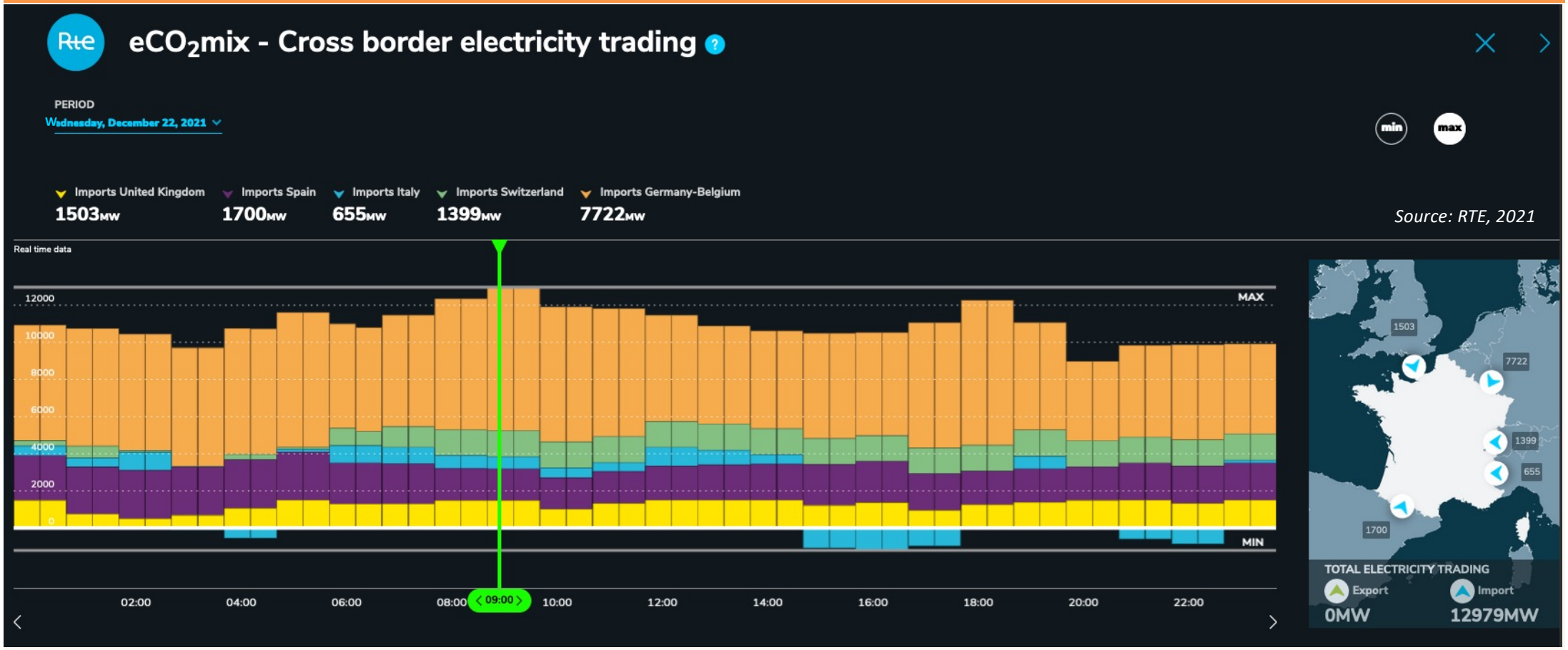


Source: https://www.rte-france.com/en/eco2mix/power-generation-energy-source

FRANCE FOCUS – 3 May 2022, 12h30, Import from Germany/Belgium >5 GW

Source: https://www.rte-france.com/en/eco2mix/power-generation-energy-source

FRANCE FOCUS – POWER EXCHANGE 22 DECEMBER 2021



French Power Trade
22 December 2021

- Net import most of the day
- Min. >9 GW net
- Max. 13 GW net *from all neighbouring countries*
- >60% from Germany / Belgium

Source: https://www.rte-france.com/eco2mix/les-echanges-commerciaux-aux-frontieres

- **Lots of media coverage**
- **Some public funding**
- **Favourable regulation**

NUCNET THE INDEPENDENT NUCLEAR NEWS AGENCY

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NUCLEAR POLITICS

France / Macron Announces Plans For First SMR And Green Hydrogen From Nuclear Plants By 2030

By David Dalton
12 October 2021

President says Europe 'will never have' enough renewable energy capacity

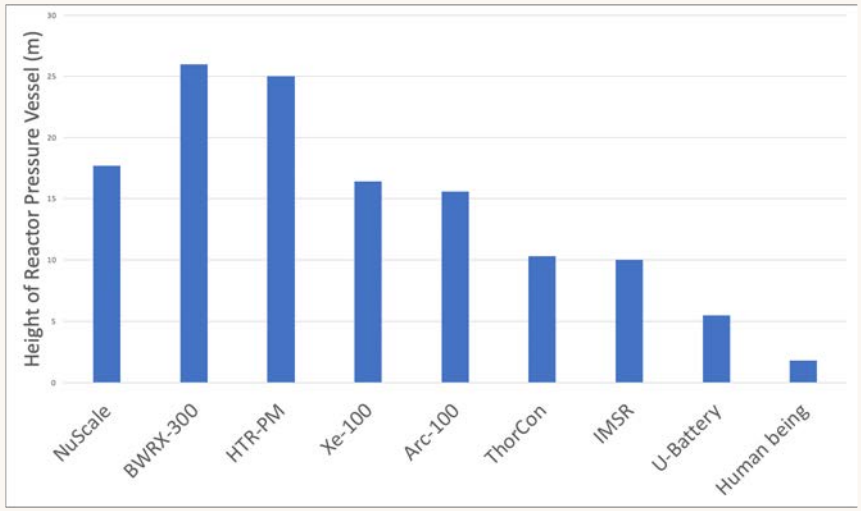
Mr Macron said France's nuclear plants are a major asset for producing clean hydrogen. Courtesy Elysée Palace.

France

- 2000-2010 (?): Areva promoted NP300
- 2011: DCNS company promoted Flexblue
- 2012 onwards: EDF-led consortium with CEA, Naval Group, and TechnicAtome, France develops NuWard design (formal announcement in 2019)
  - €50 million from French government
  - €1 billion promise from Macron

SMRs – WHAT ARE SMALL MODULAR REACTORS?

Size	Capacity
Small	< 300 MWe
Medium	300 to 700 MWe



Source : ARTE TV, https://www.arte.tv/fr/videos/107547-000-A/nucleaire-mini-reacteur-pour-maxi-controverse/

- Assembled from factory-fabricated modules
- Each module represents portion of finished plant
- Current large nuclear plants require substantial amount of field work

SMRs – PROJECT DELAYS AND POOR PERFORMANCE

- **Argentina**

  Carem-25 construction start 2014; November 2020 report: “physical completion of Carem 25 is at 70%”; completion “within 3 years”?

- **China**

  HTR-PM construction start 2012; projected to generate electricity in 2017; grid connection first unit in December 2021 (4+ years late)

- **Russia**

  KLT-40S construction start 2007; projected to start operations in October 2010; grid connection December 2019; load factors in 2020 just 29 and 16 percent (remote location)

Case Study NuScale, USA

- 2008 projection: electricity generation by 2015-16; current: 2029-30

(Westinghouse: AP1000 buildable in 3 years)

- 2020: Advisory Committee on Reactor Safeguards identification of problems with steam generator and boron dilution

- Increasing costs in UAMPS project: from $3 billion for 600 MWe (gross) in 2014 to $5.32 billion for 462 MWe (gross) in 2021 **-->** per unit cost of $11,515/kW = 80 percent more than AP1000 reactors at Vogtle when construction started (whose costs have more than doubled since then)

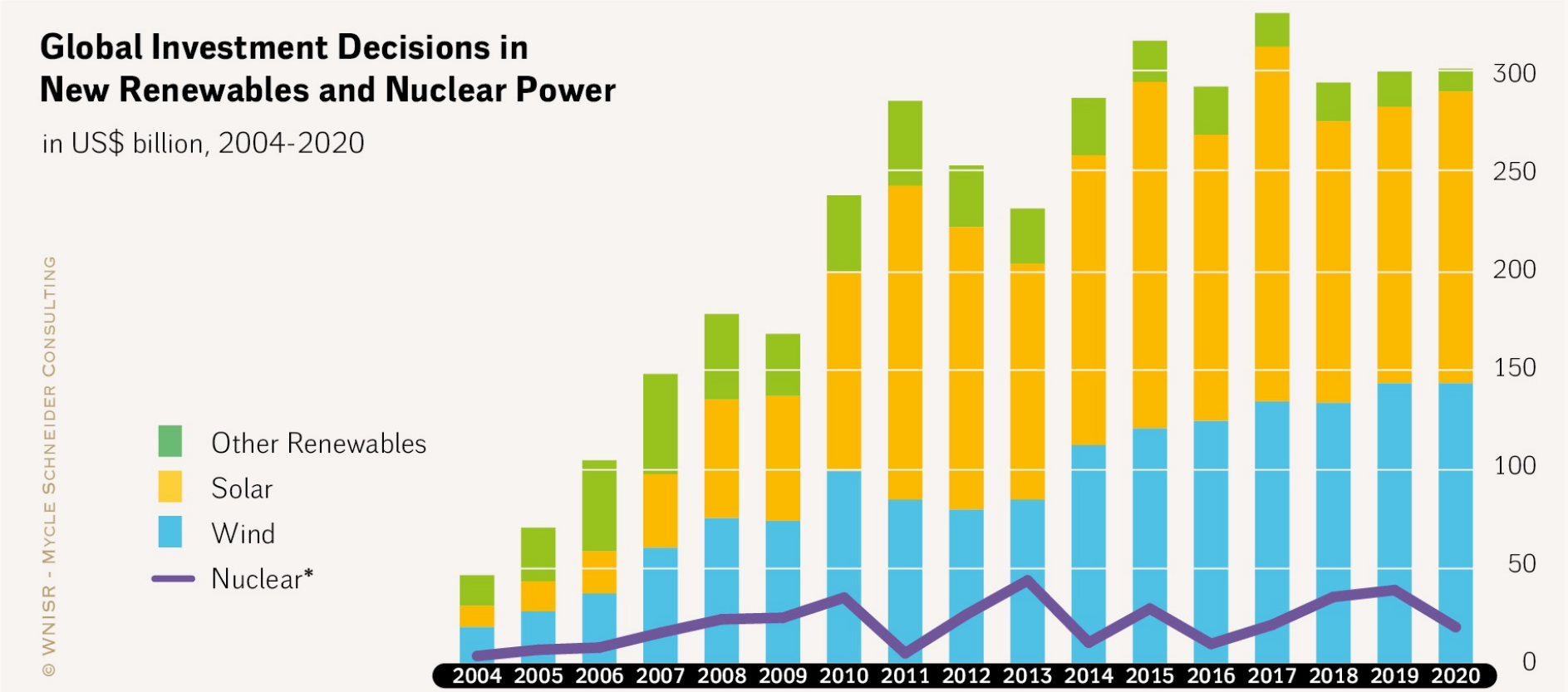
- **Loss of economies of scale**

  - Nuclear power is already costly

- **More spent fuel/proliferation potential**

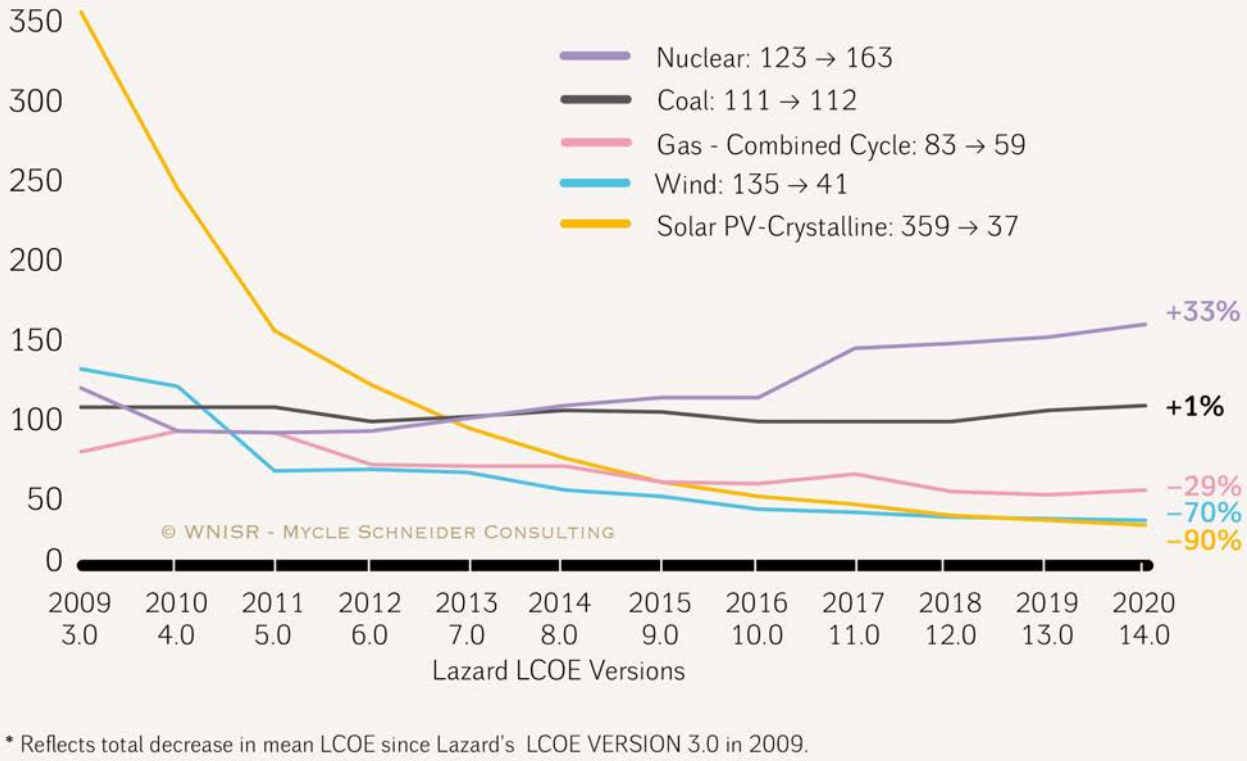
  - Accentuates problems

NUCLEAR POWER VS. RENEWABLES DEPLOYMENT



Sources: FS-UNEP/BNEF 2018, 2020, REN21 2019, BNEF 2021 and WNISR Original Research, 2021

NUCLEAR POWER VS. RENEWABLES DEPLOYMENT

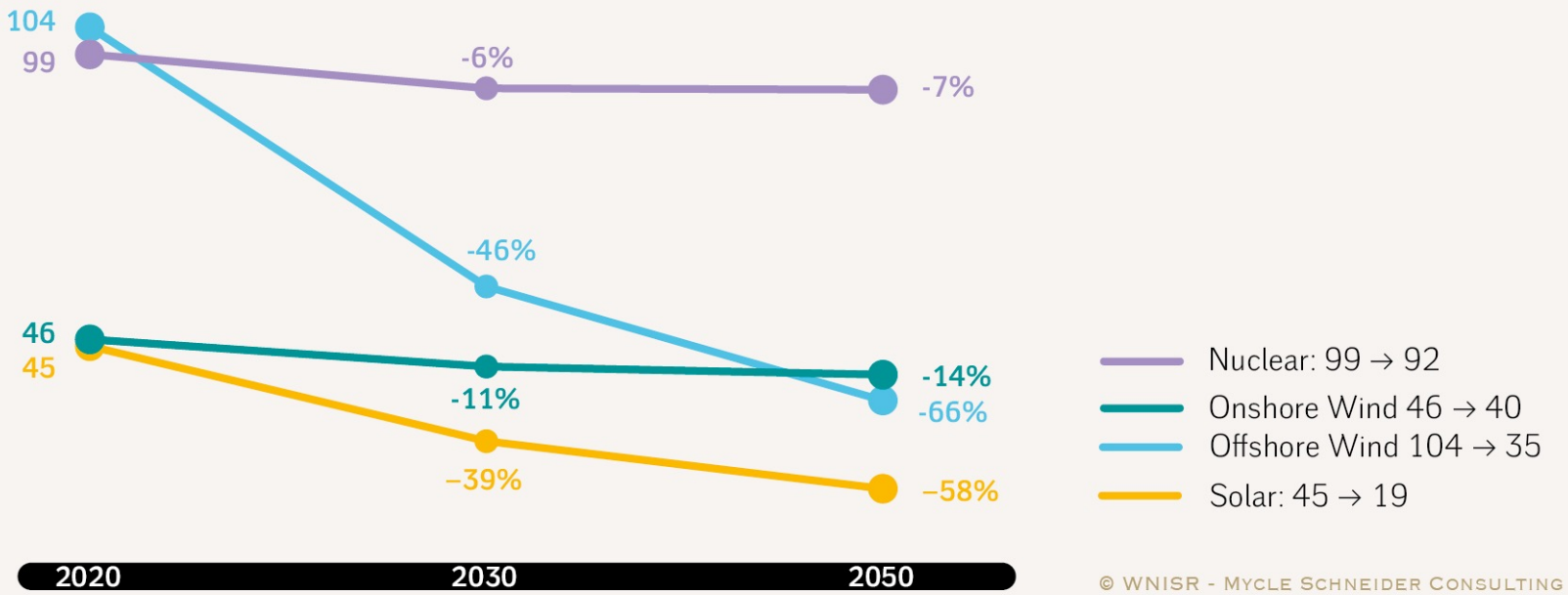


Source: Lazard Estimates, 2020

NUCLEAR POWER VS. RENEWABLES DEPLOYMENT

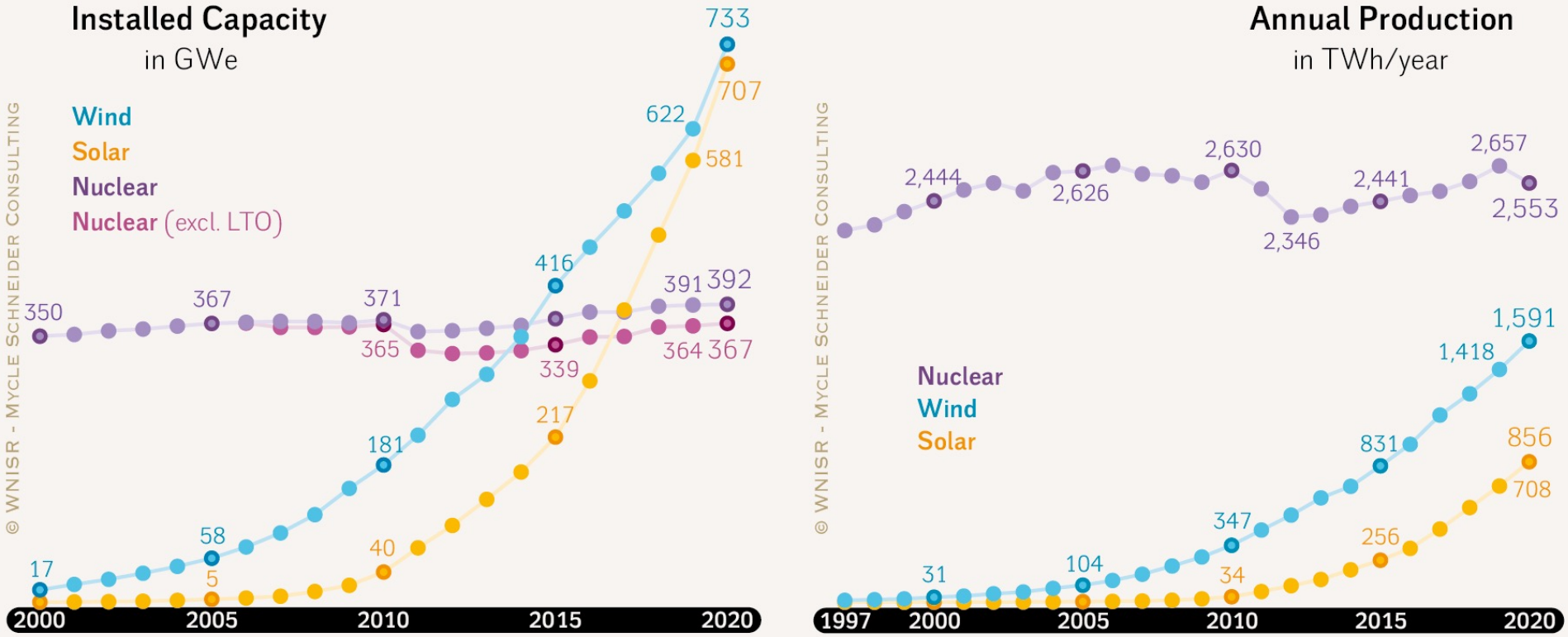
2050 Forecasted Average Cost of Electricity from Nuclear and Renewables

in US$/MWh



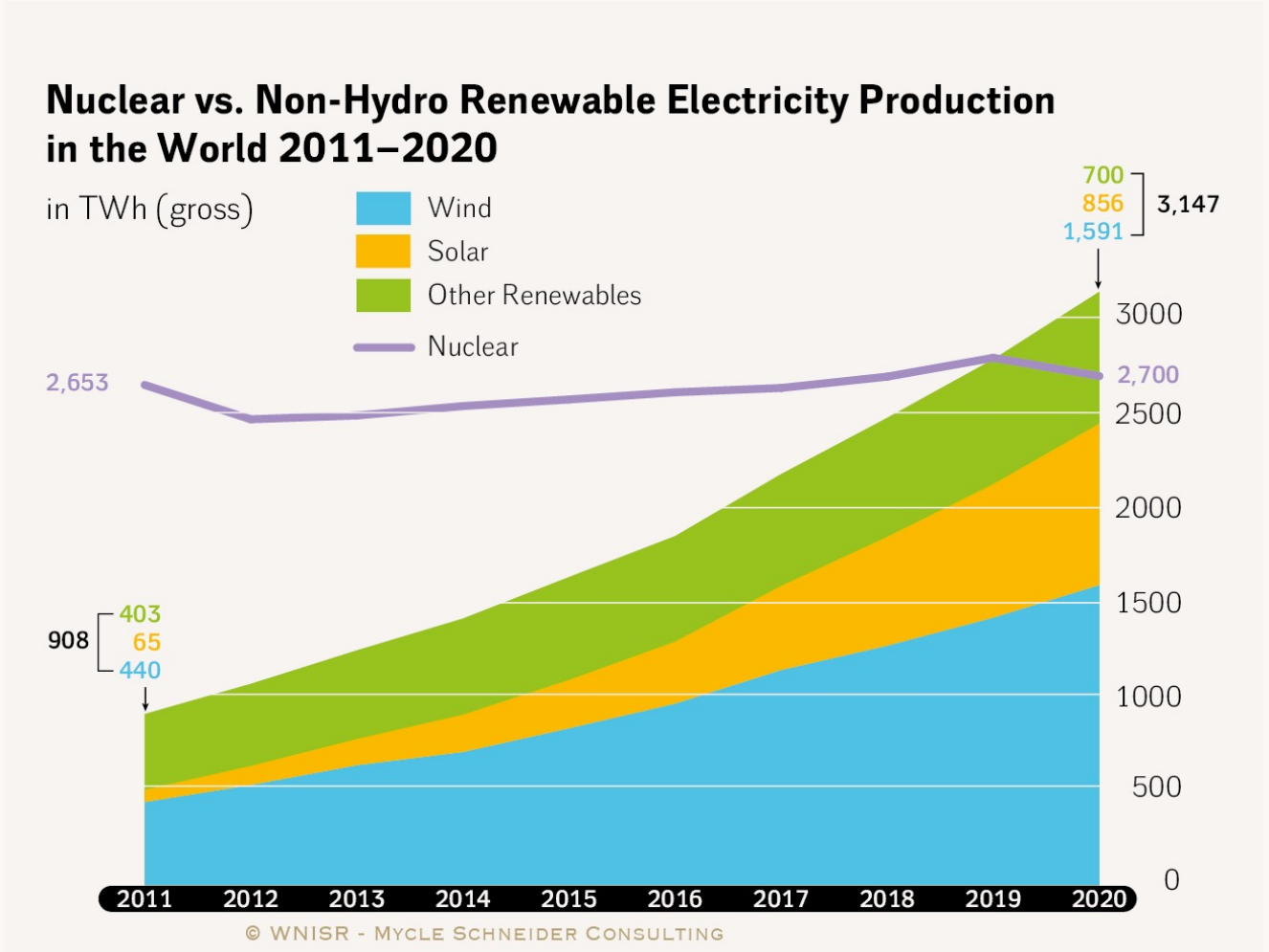
Source: IEA, 2021

Wind, Solar and Nuclear Capacity and Electricity Production in the World



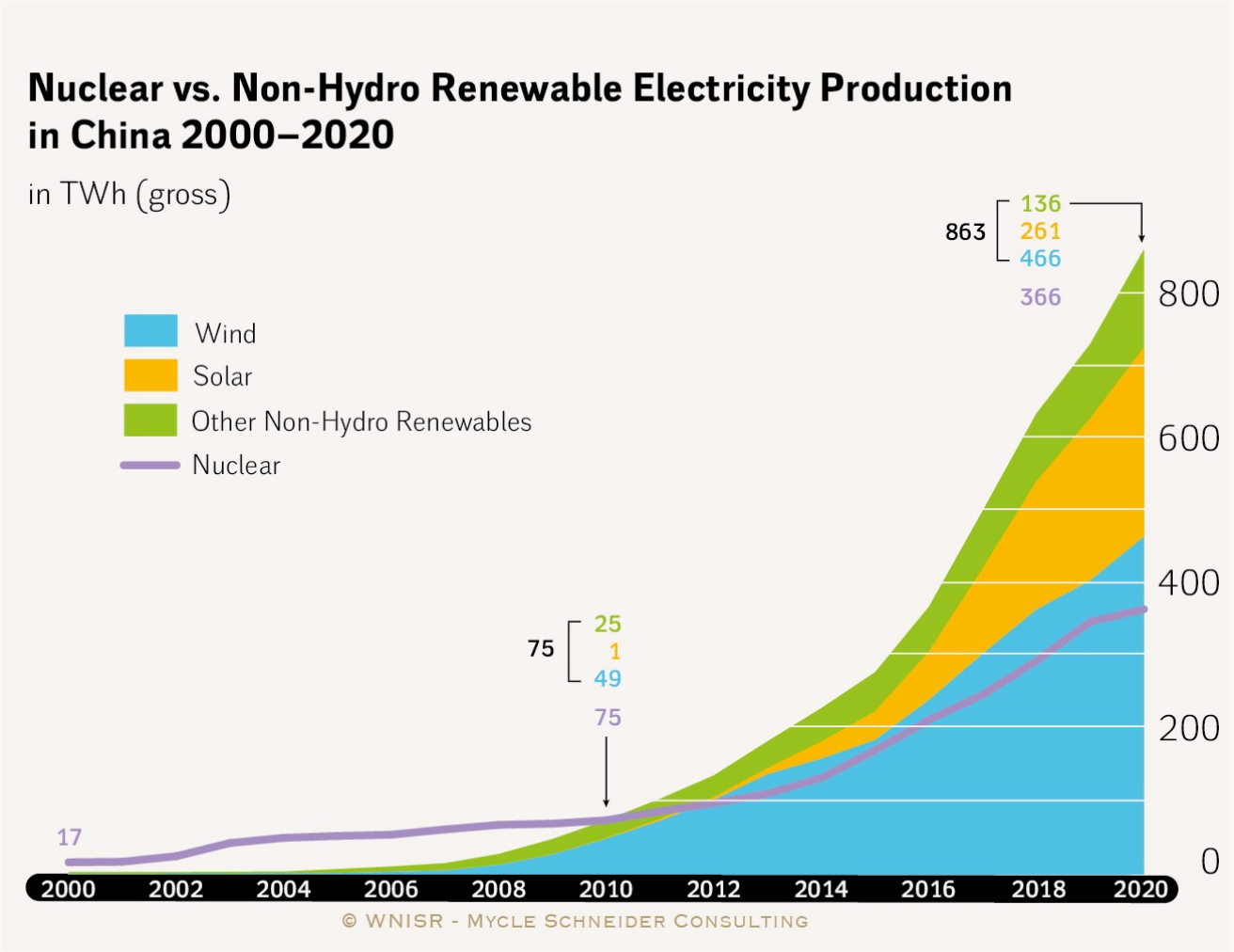
Sources: WNISR with IAEA-PRIS, IRENA, BP Statistical Review, 2021

NUCLEAR POWER VS. RENEWABLES DEPLOYMENT



Sources: BP Statistical Review, 2021

NUCLEAR POWER VS. RENEWABLES DEPLOYMENT

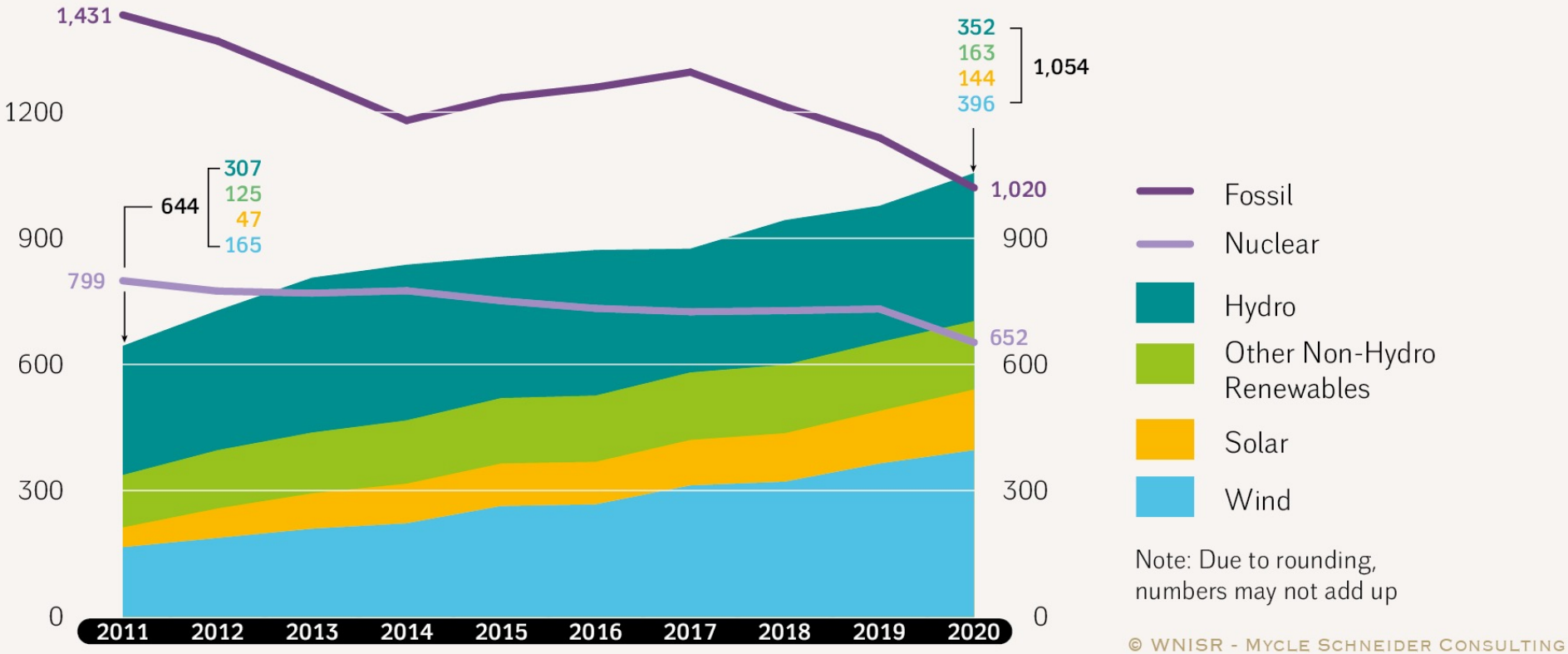


Sources: BP Statistical Review, 2021

NUCLEAR POWER VS. RENEWABLES DEPLOYMENT

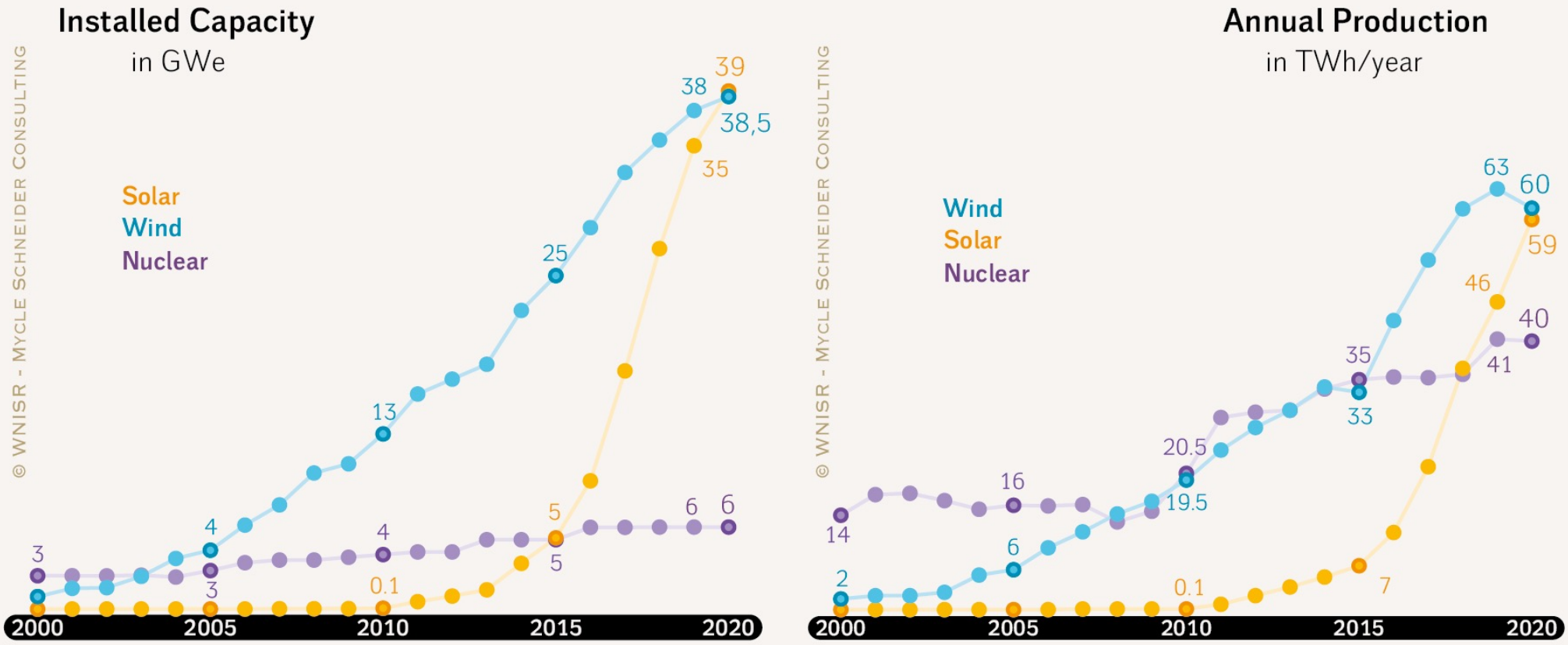
Electricity Production in the EU27 2011–2020

in TWh/year



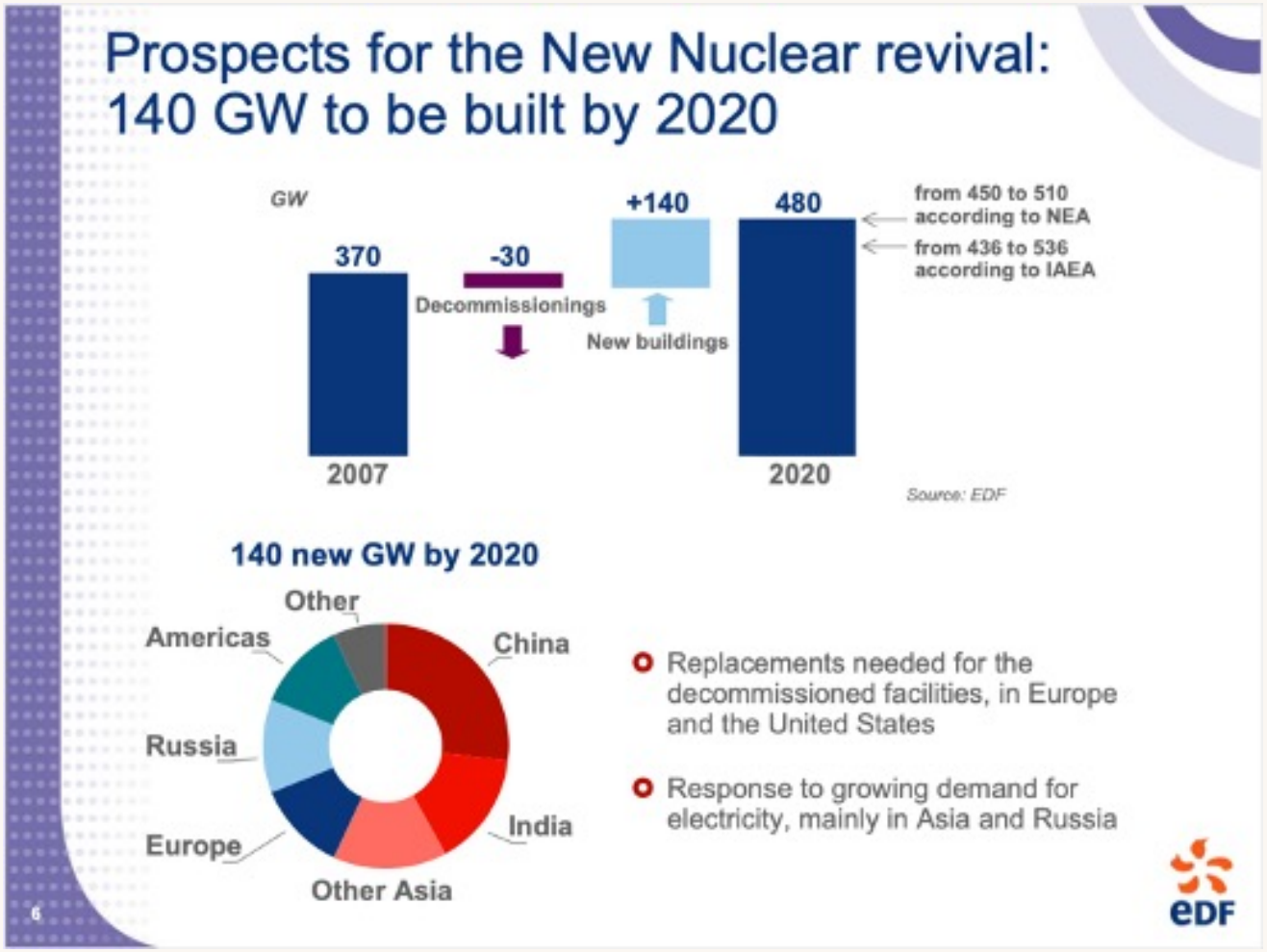
Note: Due to rounding, numbers may not add up

Wind, Solar and Nuclear Capacity and Electricity Production in India 2000–2020



Sources: WNISR with IAEA-PRIS, IRENA, BP Statistical Review, 2021

NUCLEAR RENAISSANCE? – MAYBE NOT



WNISR2008
in the *Bulletin of the Atomic Scientists*

« After thorough analysis it seems surprisingly evident that contrary to the public's perception and the industry's efforts, nuclear power will continue its long-term decline rather than move toward a flourishing future revival. »

Reality 2020
367 GW operating

CONCLUSIONS

- In 2020, nuclear power generation plunged by un an unprecedented margin except for the aftermath of 3/11 (2011–12).
- Non-hydro renewables—mainly wind, solar and biomass—have out-performed nuclear power on a global scale. Hydro alone has been generating more power than nuclear for most of the past three decades.
- For the first time, *non-hydro* renewables generated more power in the European Union than nuclear, and renewables *including hydro* generated more power than all fossil fuels combined.
- Net nuclear capacity addition—new startups minus closures—declined to 0.4 GW in 2020 and turned negative in 2021 (compared to +190 GW for renewables) with 10 units being closed (more than in any year since 2011. Nuclear is irrelevant in today's electricity capacity newbuild market.
- Small Modular Reactors (SMRs) have generated a lot of media attention but limited public funding and little progress on the ground. Pilot projects in Argentina, China, and Russia were a big deception.
- Nuclear power demonstrated a high sensibility to the COVID-19 pandemic. A first analysis shows that it has a low resilience against the most common climate change effects, which will likely further decline.
- There is a real question about the exposure of the nuclear power sector to criminal activities including bribery and corruption, counterfeiting and other falsification, as well as infiltration by organized crime.

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Mycle Schneider has given evidence or held briefings at national Parliaments in 16 countries and at the European Parliament. He has advised Members of the European Parliament from four different groups over the past 30+ years. He has given lectures or had teaching appointments at over 20 universities and engineering schools in 10 countries.