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Kuwait Foundation for the Advancement of Sciences

The Outlook for Nuclear Energy

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Edited Version of a Presentation made at the

41st Oxford Energy Seminar

20 September 2019

Oxford, UK (EU)

Provided as background information for the 23 July 2020 Seminar:

"Outlook for Nuclear Power in a Carbon Constrained World"

Outline

- Development of Nuclear Power prior to Fukushima
- Nuclear Power Post Fukushima: Status and Uncertain Outlook
- Challenges to a Robust Future Role of Nuclear Power:
- Will SMR Offer Brighter Future for Nuclear Energy
- Nuclear Fusion: The ultimate solution?

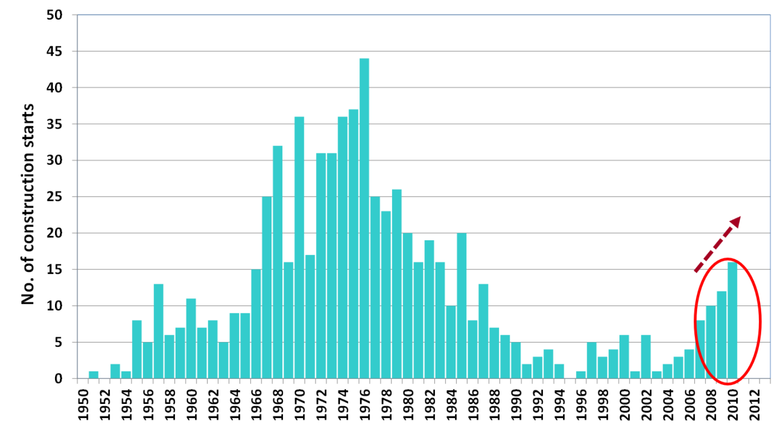
History & Development of Nuclear Power

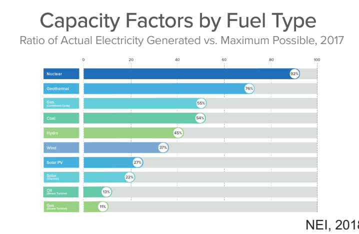
- Early optimism: “Too cheap to meter” (1953 USAEC)
- Soon, faced reality of a massive & complex industry
- It endured impact of a couple of major accidents
- Attempted Renaissance aborted each time

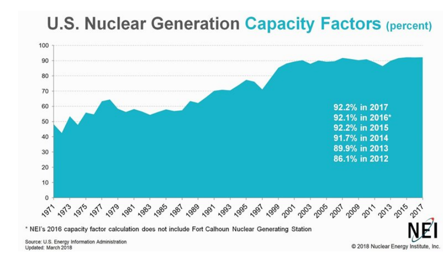
Development of Nuclear Power prior to Fukushima

- 1953: “too cheap to meter”, USAEC Chair
- Rising interest post 73
- Increasing const. delays, High inflation, and cost over-runs
- TMI 79
- Chernobyl 86
- Renewed interest post 2003:
  - Higher capacity factor; License extensions; Market in used reactor; money printing machines
- A Renaissance ?

Construction starts 1950 to 2010

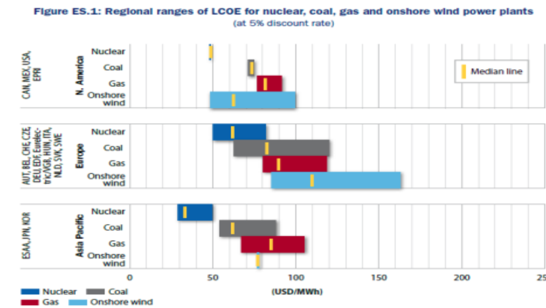


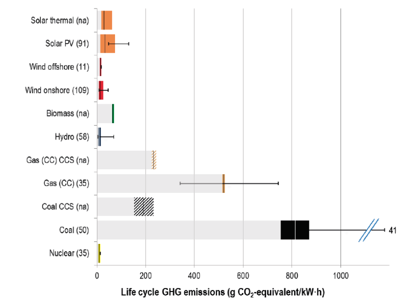




Drivers of Revived Interest in Nuclear Power Prior to Fukushima (between 2003 & end of 2010)

- **Economics Competitiveness:**
  – Competed favorably with most other available base load power generation systems.
- **Low carbon base load power option**
  – readily available to meet Climate Change challenge.
- **High level of Fuel Security for dispatchable Generation**
  – **Fuel load for several years can be stored easily at little cost.**
- **Good (relative) Safety Record, despite TMI and Chernobyl accidents**
  – Lingering questions/concerns remained of risks from future accidents at NPPs & NFC facilities (particularly the lack of verifiable & proven safe permanent waste disposal **!!??**
- **Then Fukushima !!**





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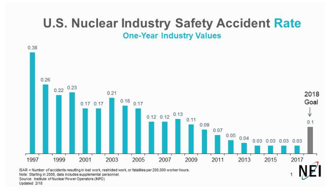
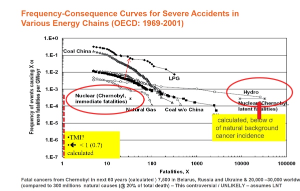
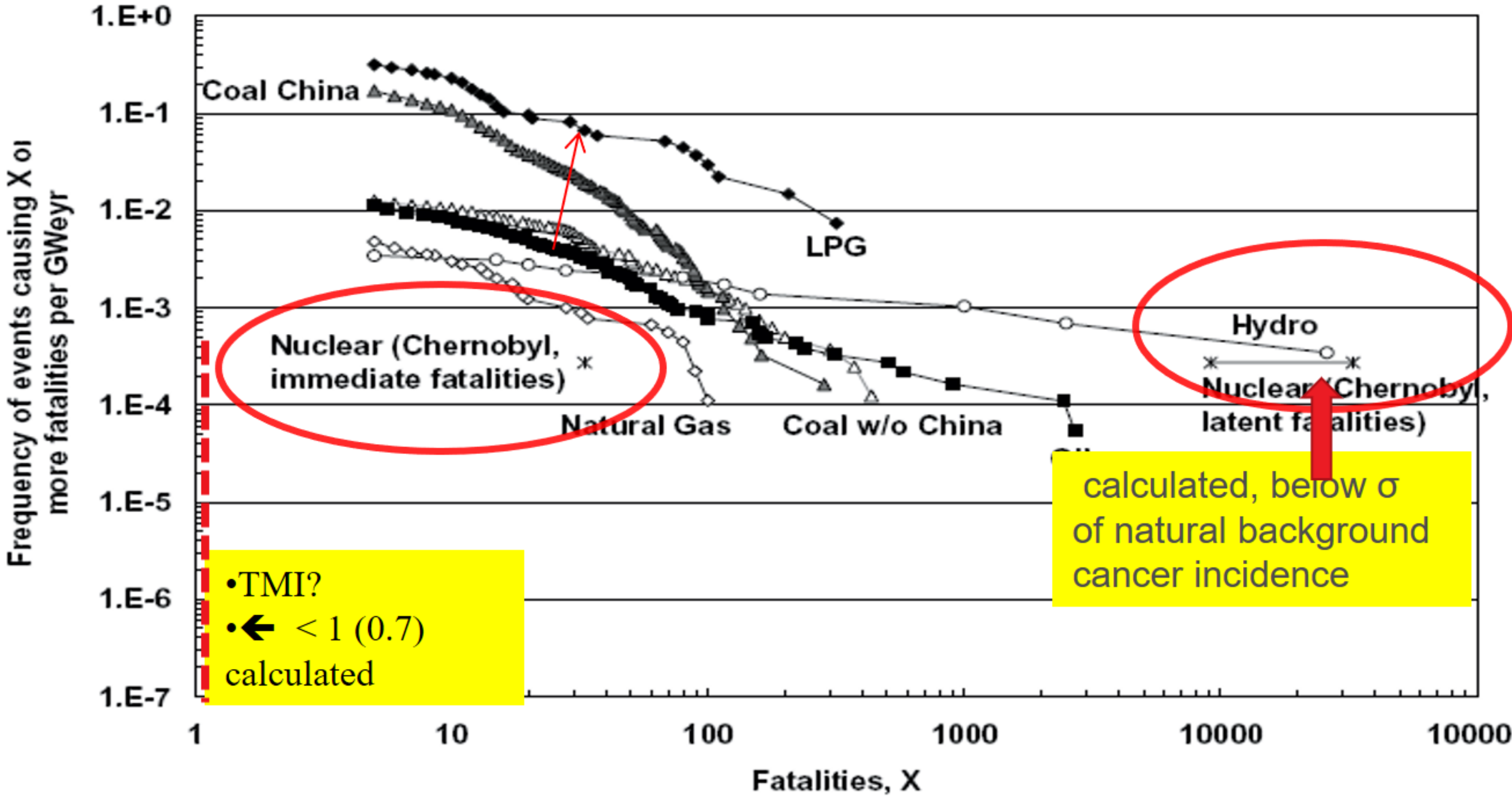




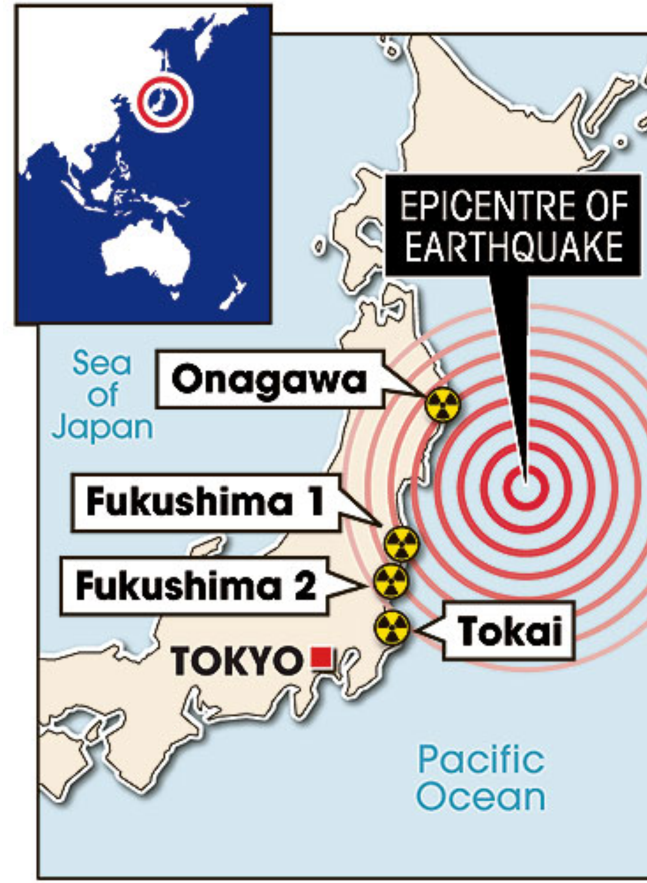
Frequency-Consequence Curves for Severe Accidents in Various Energy Chains (OECD: 1969-2001)



Fatal cancers from Chernobyl in next 60 years (calculated) 7,500 in Belarus, Russia and Ukraine & 20,000 –30,000 worldwide (compared to 300 millions natural causes (@ 20% of total death) – This controversial / UNLIKELY – assumes LNT

The Fukushima Shock: What happened & why (11.03.2011)

- @ 14:46 **Earthquake** of Magnitude 9 (acceleration at site close to design); **all reactors** (1,2 &3) **automatically shutdown**!
- @15:45 **Tsunami** wave height at site: **14 M!!!** ; (Design: 5.7 M, DG & Reactor at 10 -13 m. ➔ Historical record > 20 M!)
- **Flooded station** (D/G) ➔ Station **Blackout** (SBO)
- ➔ **loss of coolant** ➔ loss of decay heat removal
- ➔ **Core-melt** ➔ release of radioactivity & H from reactor vessel with steam being vented
- ➔ **H explosions** in 3 reactors (above 4% concentration)
- ➔ some **radioactive release** to atmosphere and sea (^{131}I and) ^{137}Cs - ~ ½ of Chernobyl total release)
- **Stabilization** (Cold shutdown) took **months** !!!
- **Mitigation** on & off site: control & disposal of contaminated water, damaged SF, remediation of site, define exclusion zones, evacuation, rehabilitation, exposure control, health impacts & regaining confidence,
- **Full Story** so far: The IAEA 2015 report



Health impact of Fukushima: WHO, UNESCAR & IAEA

Assessment of risk to public from exposure to radiation from released radioactivity

WHO 2013 Report

- For general population inside & outside Japan, predicted risks are low & no observable increases in cancer rates above baseline are anticipated.
- "however, estimated risk for specific cancers in certain subsets of the population in Fukushima Prefecture has increased;
- it calls for long term continued monitoring and health screening for those people

UNESCAR 2014 Report & 2016 WP

- "No discernable increases in radiation related health effects are expected among members of public or their descendent"
- "The most important health effect is on social and well being related to the impact of the earthquake , tsunami & fear related to perceived risk of radiation"

The IAEA Encyclopedic report (2015), & updates

2018 Update:

- There were no acute radiation injuries or deaths among the workers or the public due to exposure to radiation resulting from FDNPS accident; Considering the level of estimated doses, the lifetime radiation-induced cancer risks other than thyroid are small and much smaller than the lifetime baseline cancer risks.
- Regarding the risk of thyroid cancer in exposed infants and children, the level of risk is uncertain since it is difficult to verify thyroid dose estimates by direct measurements of radiation exposure.

Source: WHO, 2013); WHO Chernobyl 2016 update:;UNSCAR 2014 http://www.unscear.org/,, UNESCAR 2016 white paper:; IAEA DG report on Fukushima Daiichi Accident, GC/59, 2015;

Lesson Learned

like Chernobyl, Profoundly Man made

- "In 2006 Japan revised standards for seismic resistance. … TEPCO needed to implement reinforcement. …could not exclude …Earthquake damaged critical reactor components.."
- "NISA and TEPCO were aware of the need to improve safety before 2011
- "The accident was a profoundly man made disaster that could and should have been foreseen and prevented"
- "Its fundamental causes are to be found in the ingrained conventions of Japanese Culture"

Response varied

from political, to prudently cautious (Stress Tests), wait & see

- Initial impact of responses was mixed; But Renaissance stalled & combined with other factors, Nuclear Power is no longer a viable option in most OECD
- Decisions by few OECD countries has a powerful multiplier effect; impact will last for at least another decade.
- Germany's Energywende: succeeded in increasing installed renewable capacity : from 11.4 → 112 GW (2002-2019)
- but at what cost? enormous overcapacity: 215 GW (Max. Consumption ~ 83 GW)

Uncertain growth outlook for Nuclear Power: Revival, then post Fukushima Brown-out

The role of nuclear energy, in the world's energy transition?

Is it still indispensable as part of response to climate change?

If as Paris Agreement aims to keep rise in T below 1.5,
Then most likely: Yes

Is it likely to play an important role by 2050?
Not clear! but likely-to-may-be,
but must overcome major obstacles/challenges

Nuclear Power Today

Nuclear Power Status 2018

Reactors in operation

396 413 MW(e) total net capacity

2 563 TWh electricity supplied

450 Nuclear power reactors

Reactors under construction

56 643 MW(e) total net capacity

55 Nuclear power reactors

Operating experience

17 881 Reactor-years of operation

IAEA

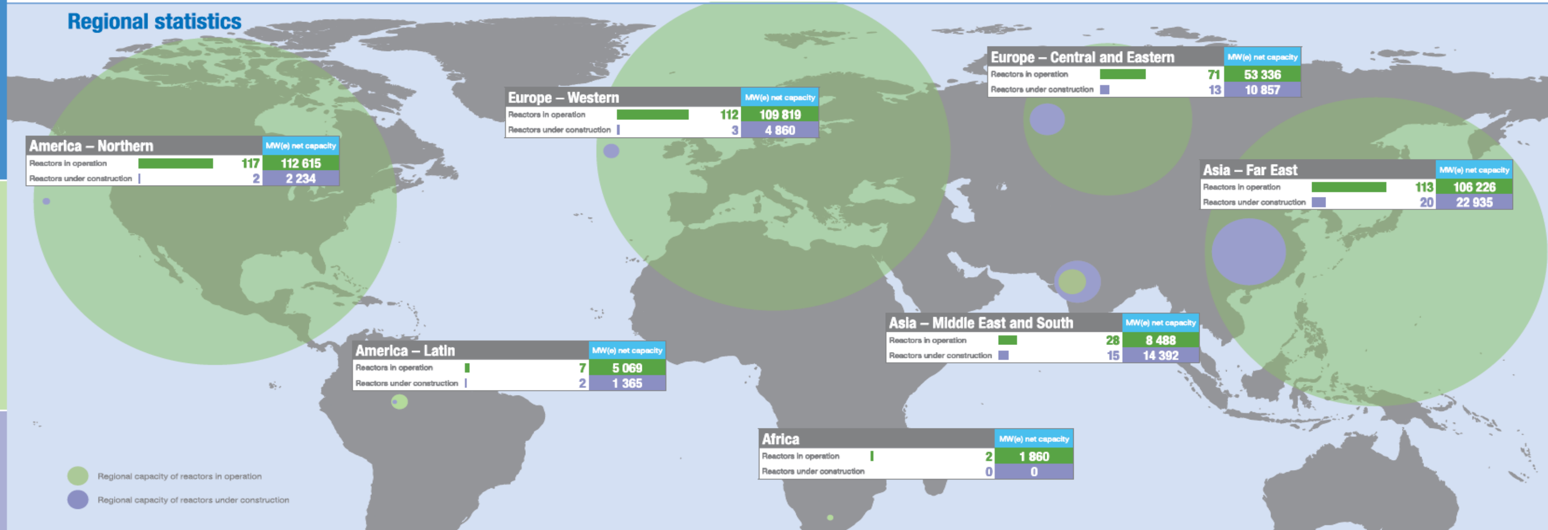
Power Reactor Information System

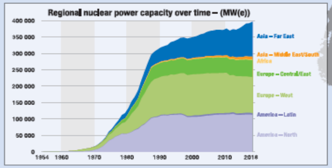
PRIS

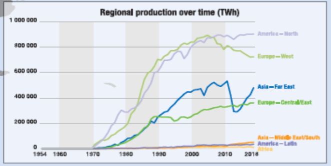
Status changes

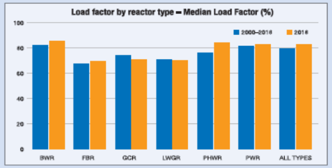
Construction starts	AKKUYU-1 HINKLEY POINT C-1	1114 MW(e), PWR, TURKEY 1630 MW(e), PWR, UK	KURSK 2-1	1175 MW(e), PWR, RUSSIA	ROOPPUR-2	1080 MW(e), PWR, BANGLADESH	SHIN-KORI-6	1340 MW(e), PWR, REP. OF KOREA
New connections to the grid	HAIYANG-1 HAIYANG-2 LENINGRAD 2-1	1126 MW(e), PWR, CHINA 1126 MW(e), PWR, CHINA 1101 MW(e), PWR, RUSSIA	ROSTOV-4 SANMEN-1	950 MW(e), PWR, RUSSIA 1157 MW(e), PWR, CHINA	SANMEN-2 TAISHAN-1	1157 MW(e), PWR, CHINA 1660 MW(e), PWR, CHINA	TIANWAN-4 YANGJIANG-5	1060 MW(e), PWR, CHINA 1021 MW(e), PWR, CHINA
Permanent shutdowns	CHINSHAN-1 IKATA-2	604 MW(e), BWR, TAIWAN, CHINA 538 MW(e), PWR, JAPAN	LENINGRAD-1 OHI-1	925 MW(e), LWGR, RUSSIA 1120 MW(e), PWR, JAPAN	OHI-2 ONAGAWA-1	1120 MW(e), PWR, JAPAN 498 MW(e), BWR, JAPAN	OYSTER CREEK	619 MW(e), BWR, USA

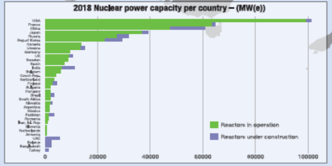
Regional statistics











Country statistics

Reactors in operation · Reactors under construction · Electricity supplied (TWh) · % Nuclear share

Country	Reactors in operation	Reactors under construction	Electricity supplied (TWh)	Nuclear share
Argentina	3	1	6.5	4.7%
Armenia	1	0	1.9	25.6%
Belgium	7	0	27.3	39%
Brazil	2	1	14.8	2.7%
Bulgaria	2	0	15.4	34.7%
Canada	19	0	94.4	14.9%
China	46	11	277.1	4.2%
Czech Republic	6	0	28.3	34.5%
Finland	4	1	21.9	32.4%
France	58	1	395.9	71.7%
Germany	7	0	71.9	11.7%
Hungary	4	0	14.9	50.6%
India	22	7	35.4	3.1%
Islamic Republic of Iran	1	0	6.3	2.1%
Japan	38	2	49.3	6.2%
Republic of Korea	24	5	127.1	23.7%
Mexico	2	0	13.2	5.3%
Netherlands	1	0	3.3	3.1%
Pakistan	5	2	9.3	6.8%
Romania	2	0	10.5	17.2%
Russia	36	6	191.3	17.9%
Slovakia	4	2	13.8	55%
Slovenia	1	0	5.5	35.9%
South Africa	2	0	10.6	4.7%
Spain	7	0	53.4	20.4%
Sweden	8	0	65.9	40.3%
Switzerland	5	0	24.5	37.7%
Ukraine	15	2	79.5	53%
United Kingdom	15	1	59.1	17.7%
United States	98	2	808.0	19.3%

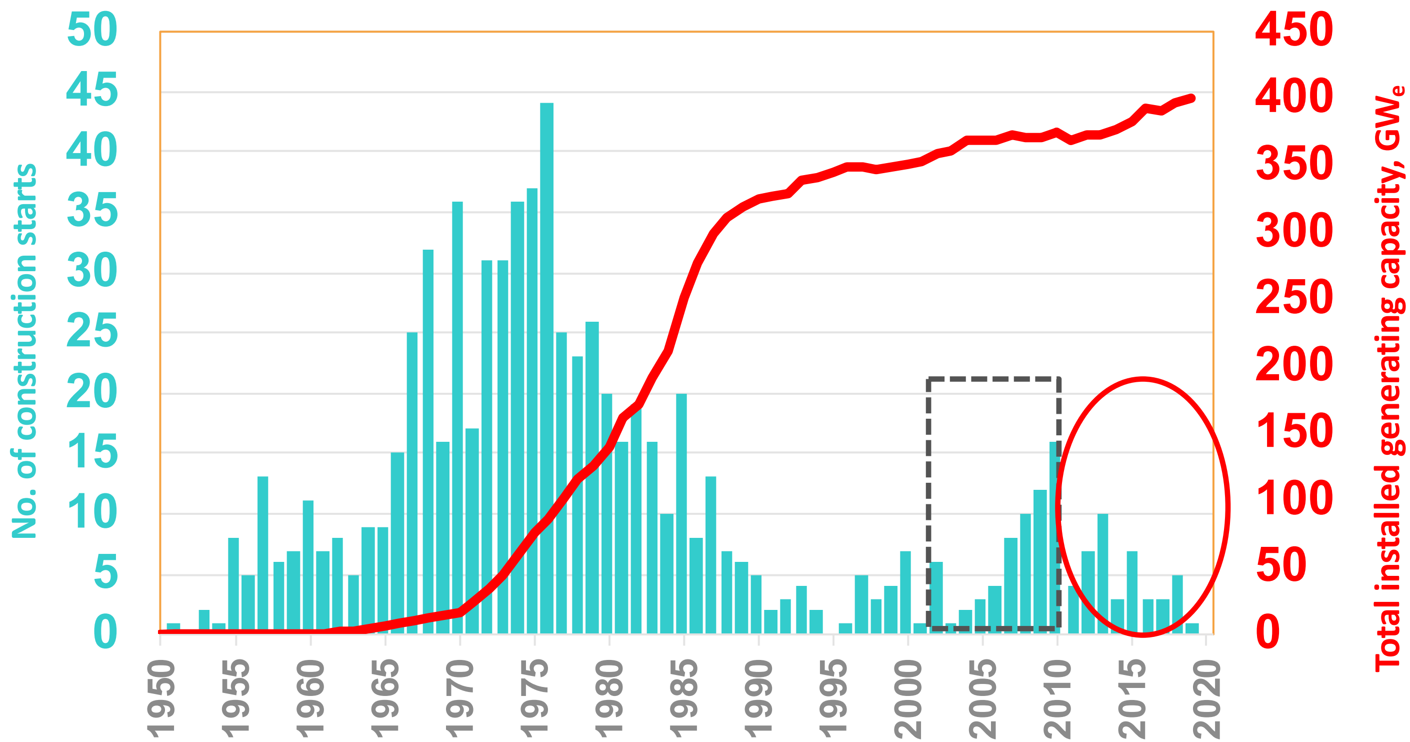
Taiwan, China: 5 reactors, 4 448 MW(e) in operation; 2 reactors, 2 600 MW(e) under construction; 26.7 TWh electricity supplied, 11.4% nuclear share.

Data are as reported – 30 June 2019

www.iaea.org/pris

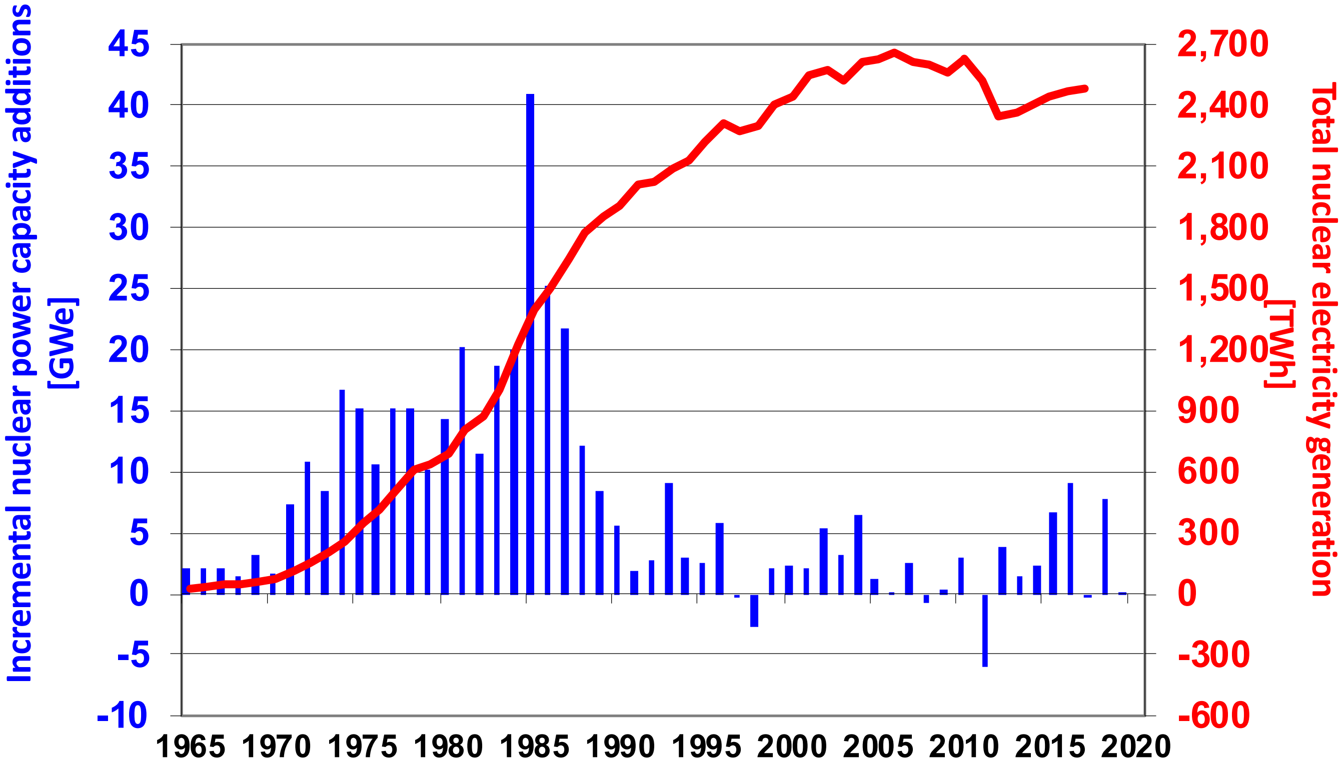
19-01767E

Construction starts 1950 to 2019



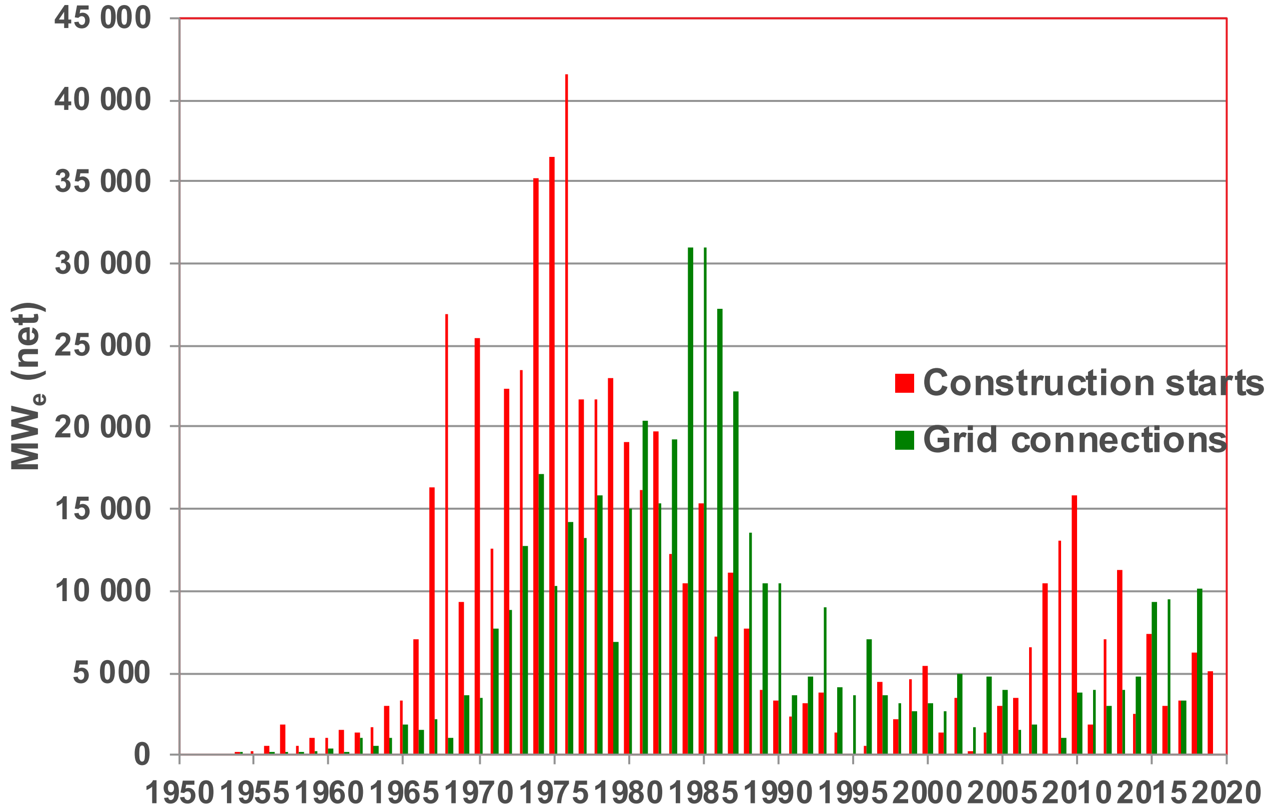
As per 17 September 2019
Source: H.H. Holger, Adapted from IAEA - PRIS

Incremental nuclear power capacity additions (GWe) and nuclear electricity generation (TWh)



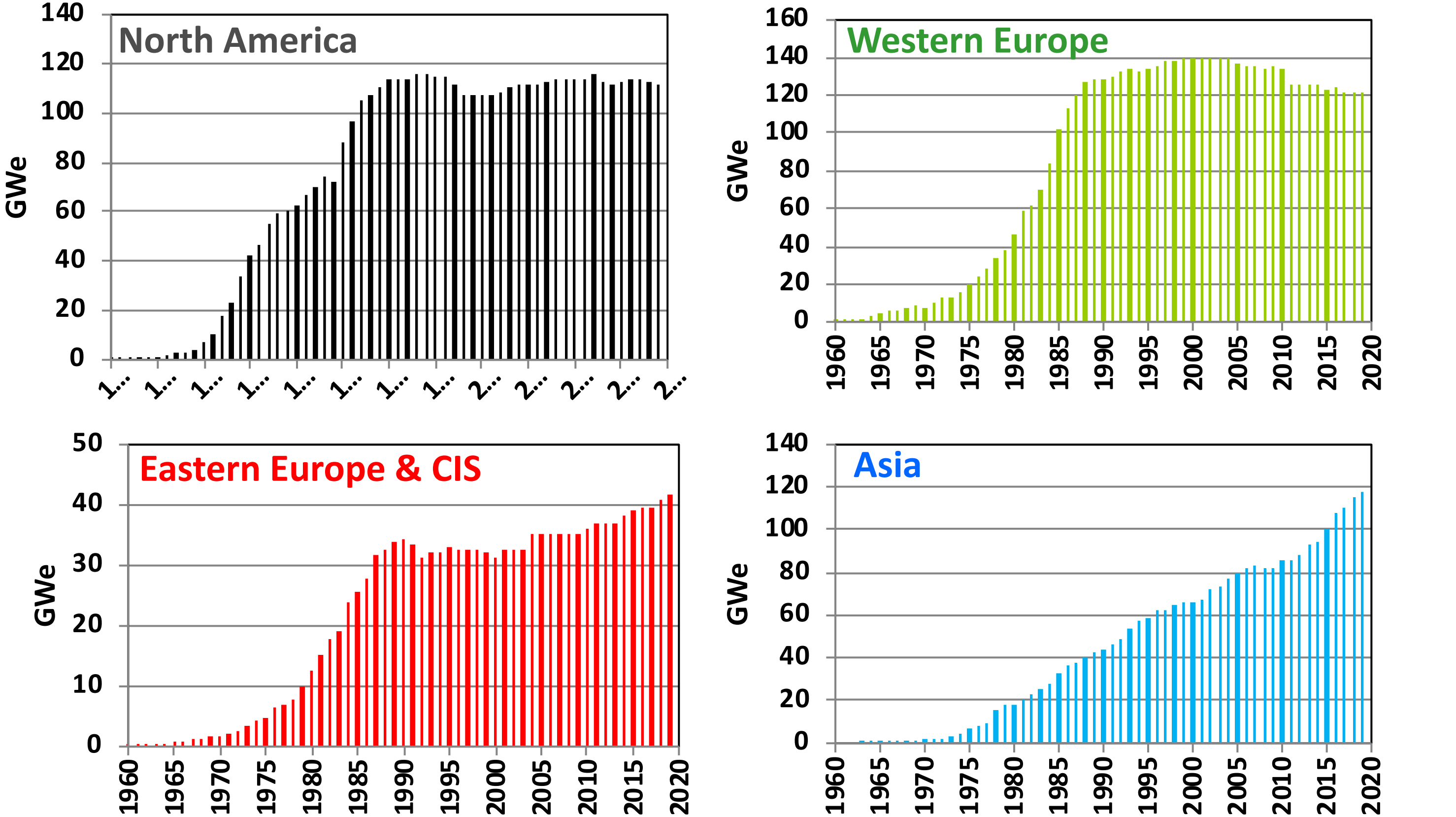
As per 17 September 2019
Source: H.H. Holger, Adapted from IAEA - PRIS

Construction starts & grid connections



As per 17 September 2019
Source: H.H. Holger, Adapted from IAEA - PRIS

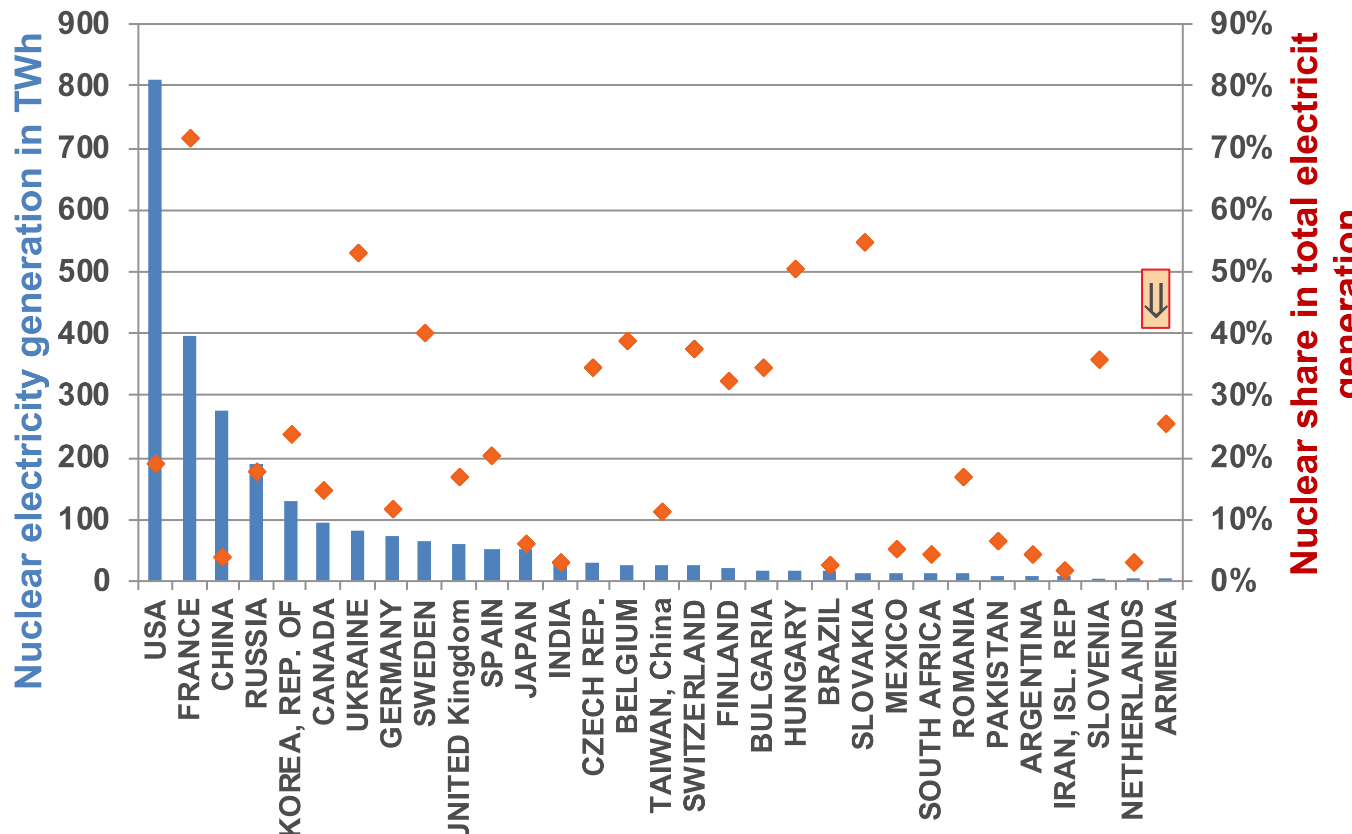
Development of regional nuclear generating capacities



As per 17 September 2019

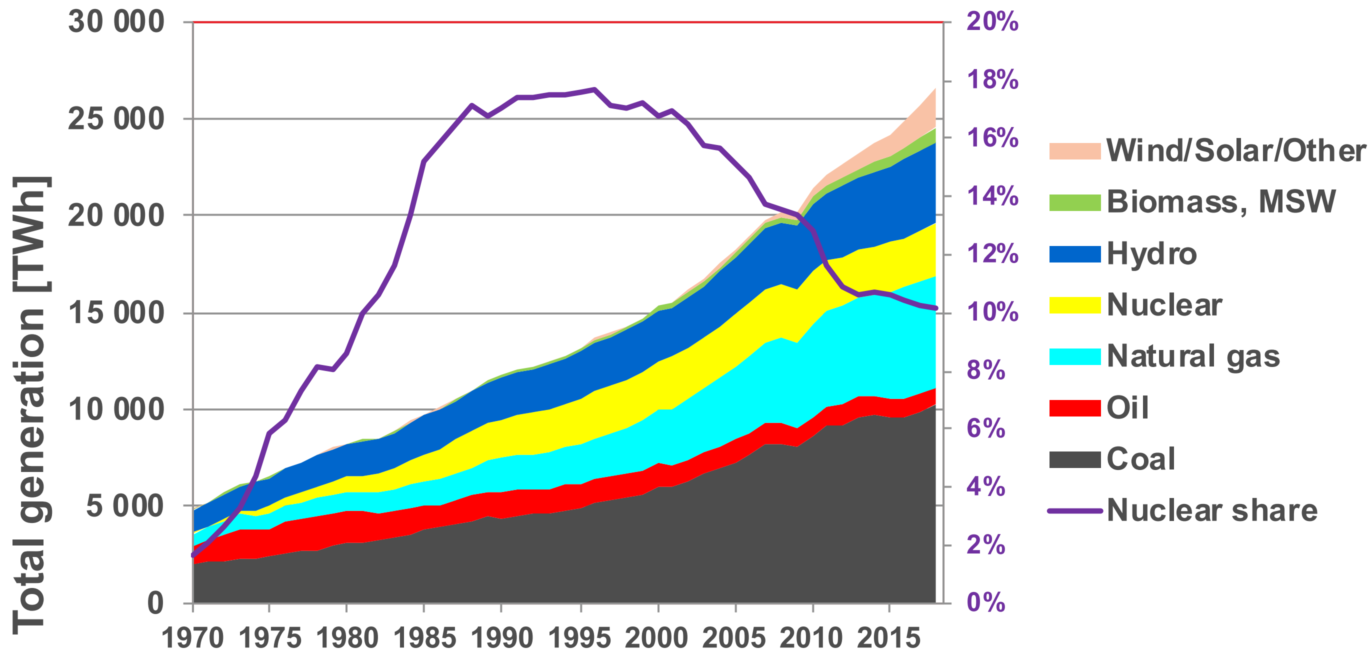
Source: H.H. Holger, Adapted from IAEA - PRIS

Country specific nuclear shares in electricity generation, 2018



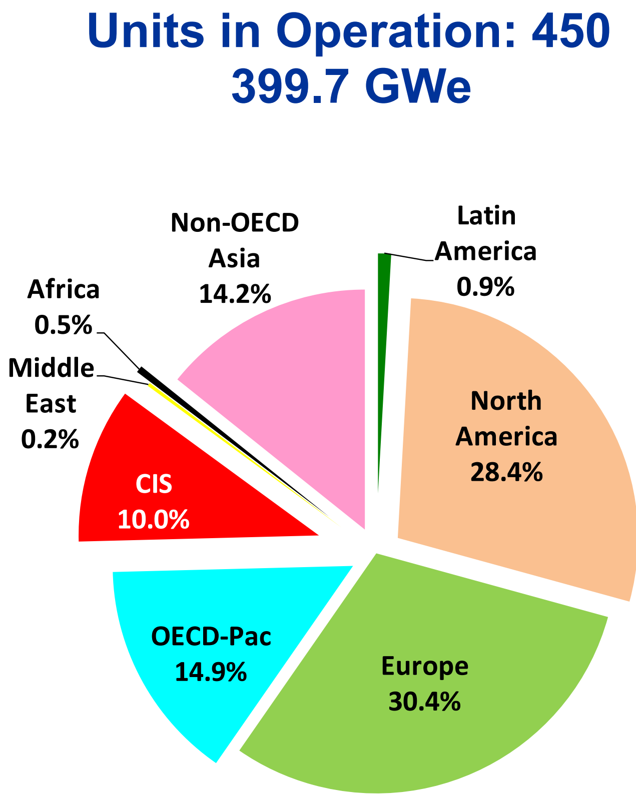
Source: IAEA - PRIS

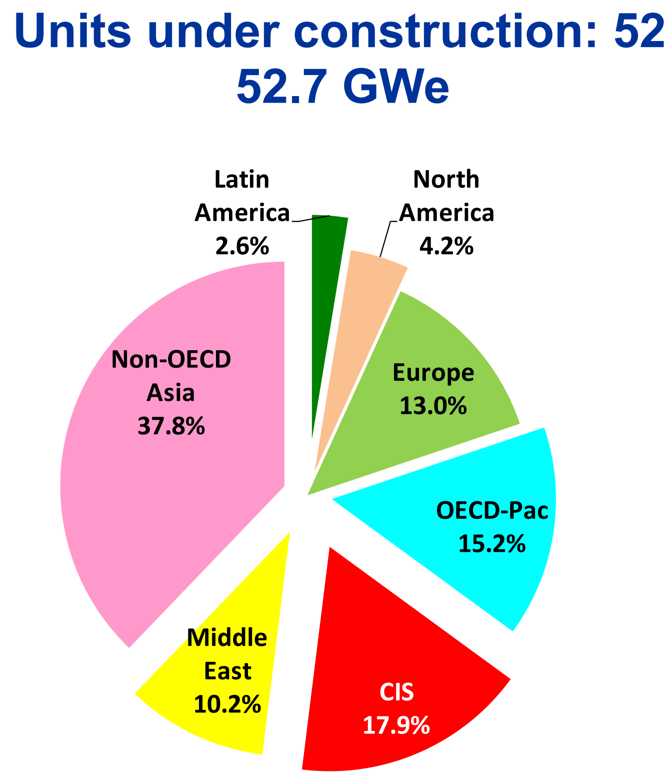
Historical development of the global electricity generating mix and the share of nuclear power



1960+, Growth, 1979+ first brown-out, 2002+ revival, 2011+ another brownout, current fading in OECD) with new built mainly in China, Asia & developing countries

Status global nuclear power

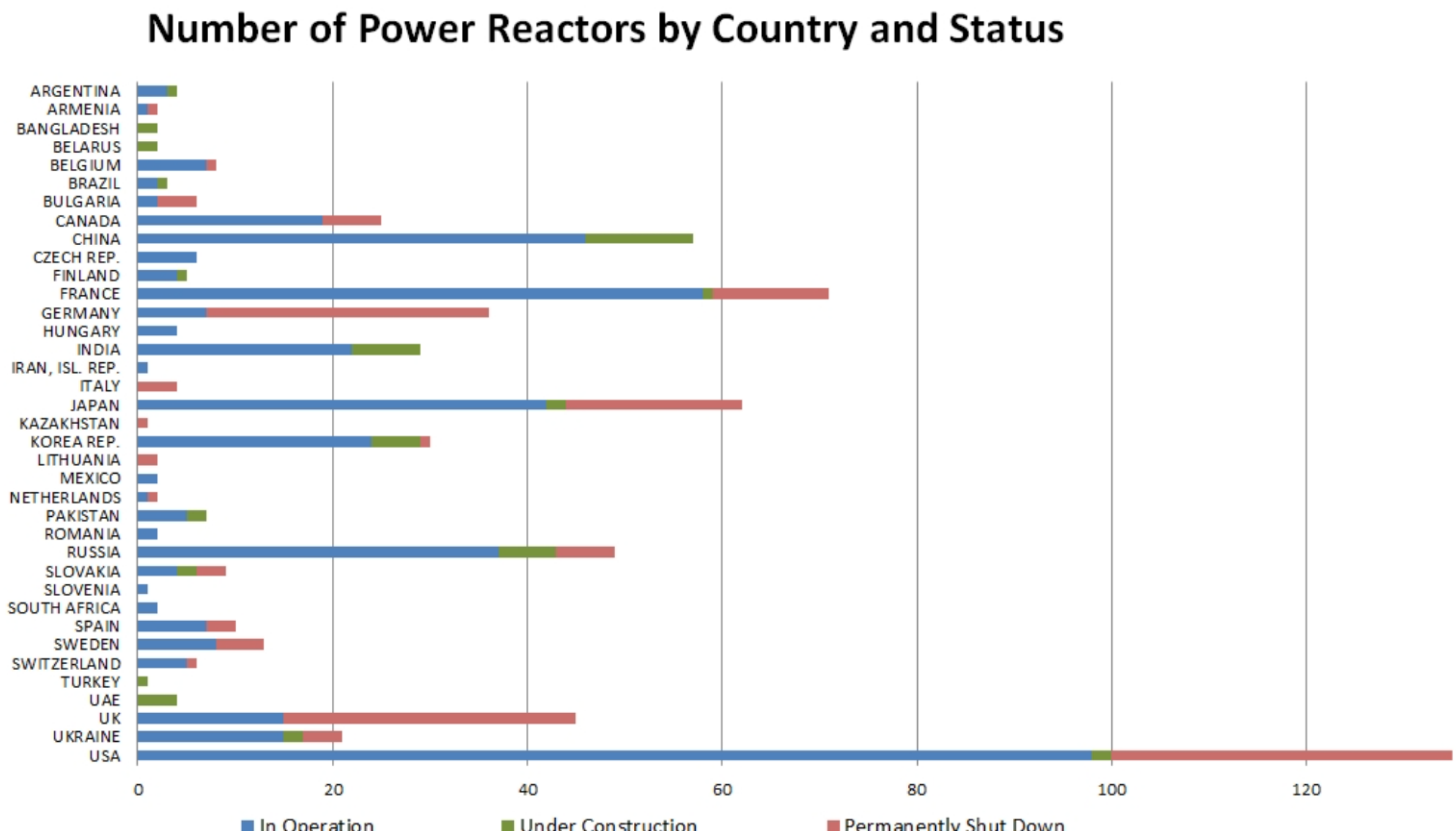




As per 17 September 2019
Source: H.H. Holger, Adapted from IAEA - PRIS

Number of Power Reactors by Country and Status

- Text
- Text
- Text
- Text

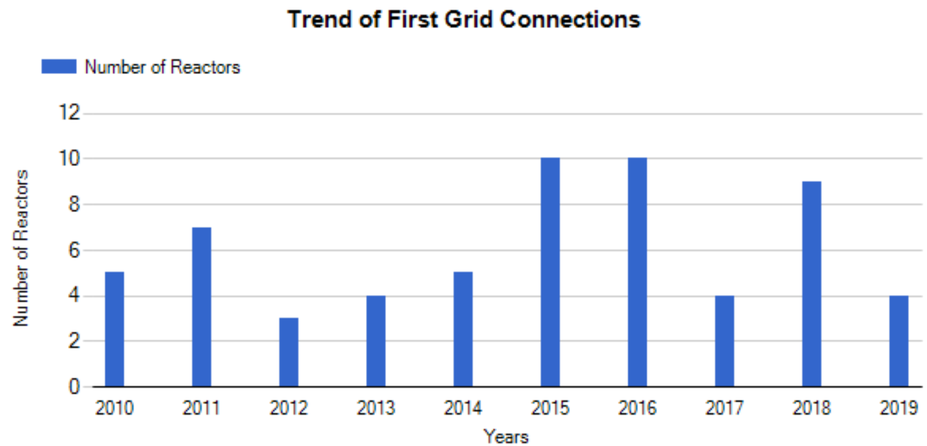


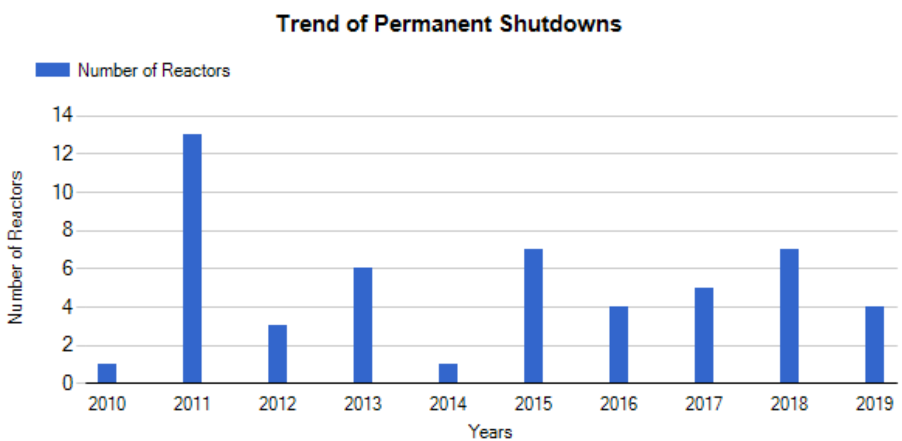
Source: IAEA – PRIS, 2019

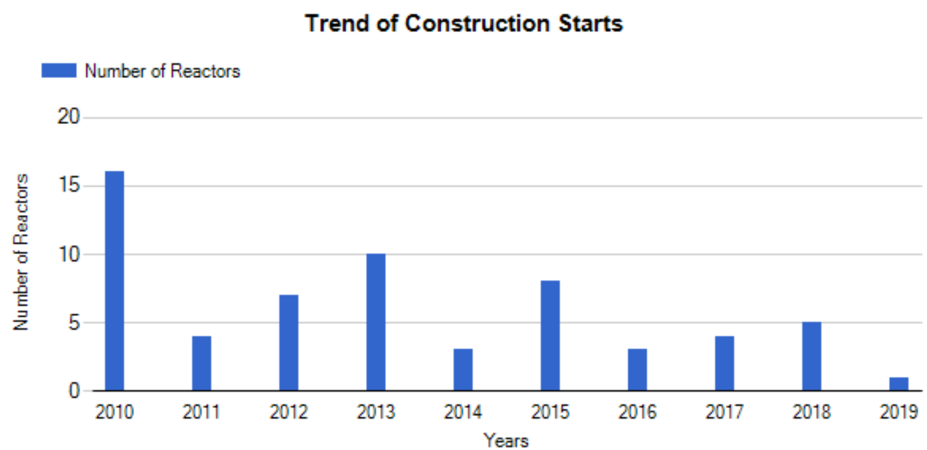
Industry Trends over last 10 years -

- **Trends of First Connection**
- **Trends of Construction Starts**
- **Trends of Permeant Shutdowns**

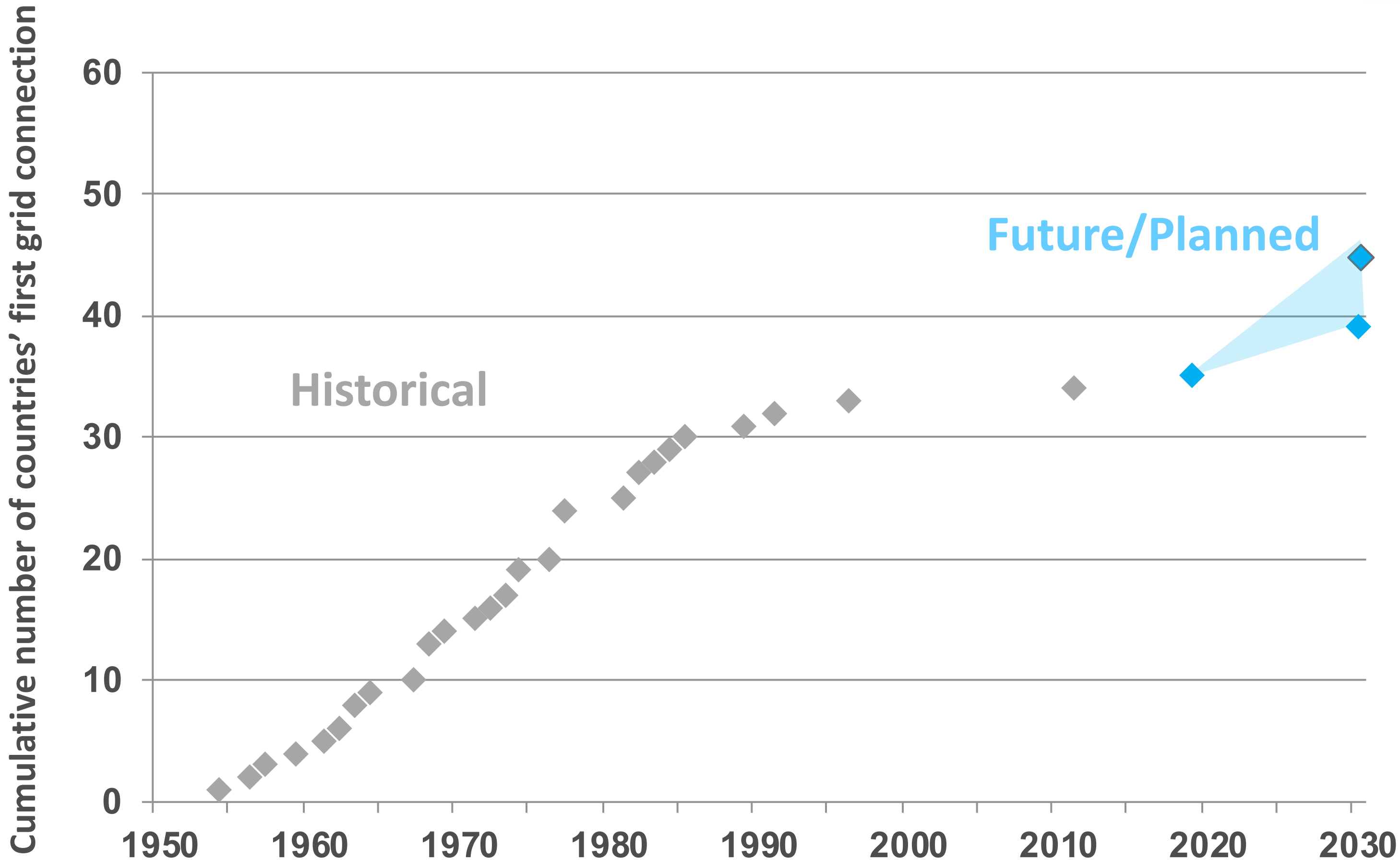
NOT A ROBUST INDUSTRY







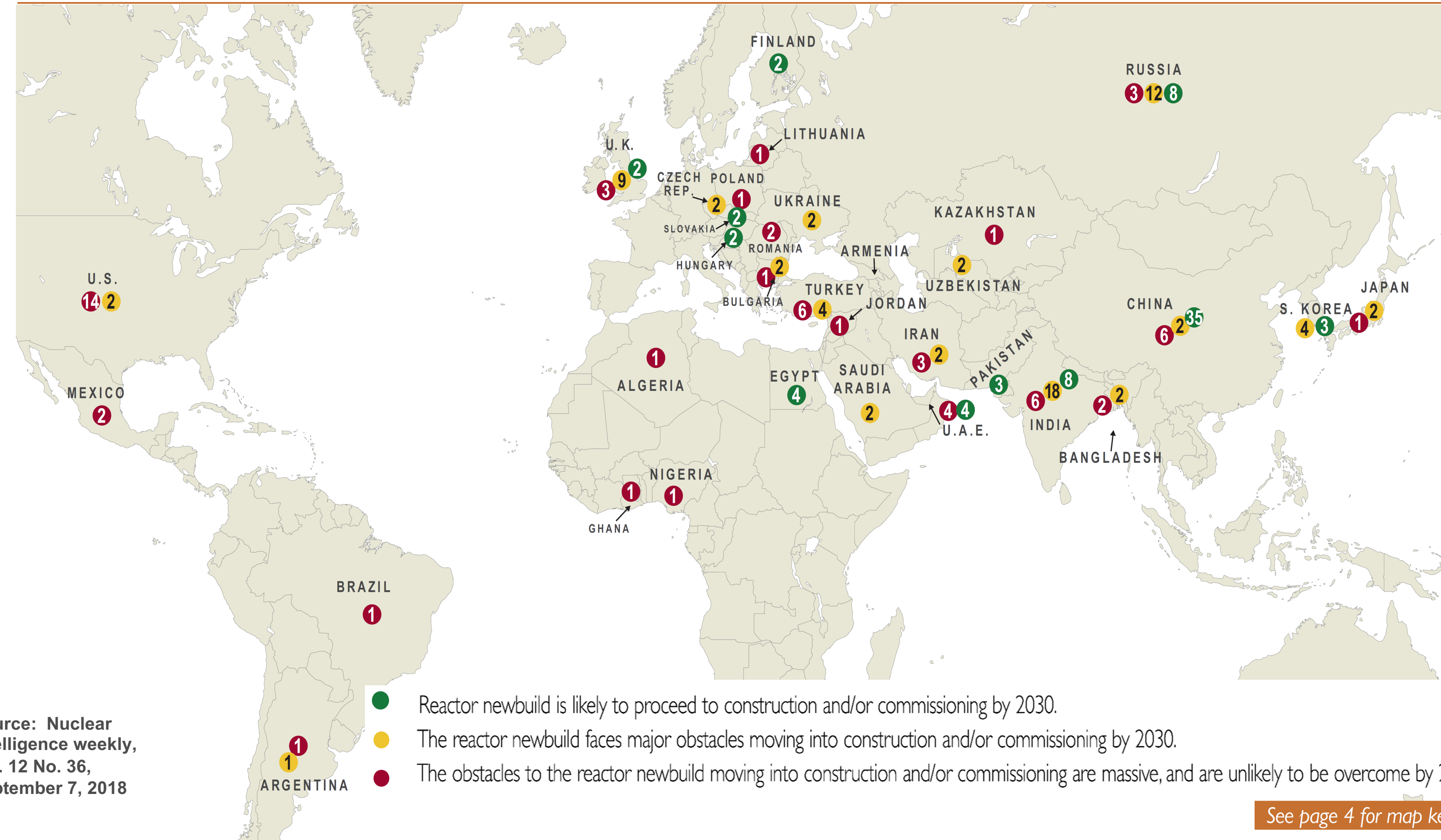
Newcomers to nuclear power



Sources: H.H. Holger, adopted from IEA, IAEA, WNA, 2018

Nuclear power today

NIW Projections for Reactor Newbuild Projects by 2030



- Reactor newbuild is likely to proceed to construction and/or commissioning by 2030.
- The reactor newbuild faces major obstacles moving into construction and/or commissioning by 2030.
- The obstacles to the reactor newbuild moving into construction and/or commissioning are massive, and are unlikely to be overcome by 2030.

Source: Nuclear Intelligence weekly, Vol. 12 No. 36, September 7, 2018

See page 4 for map key

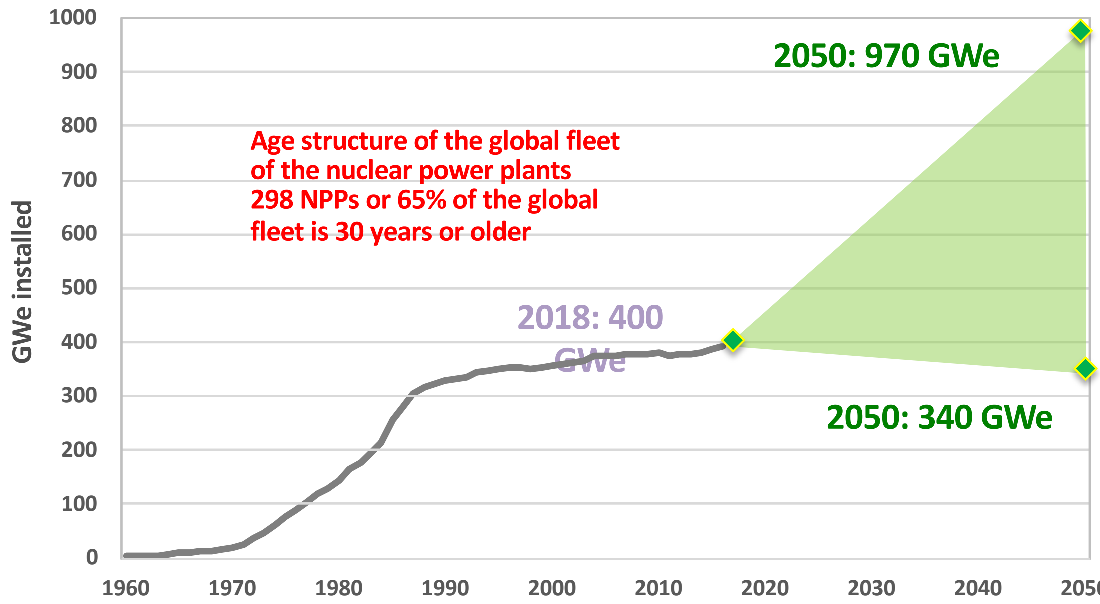
Outlook for Nuclear Power
(post Fukushima brown-out)

covering periods 2030 through 2050

Includes changes of IAEA's High & Low Projections (2011-2019)

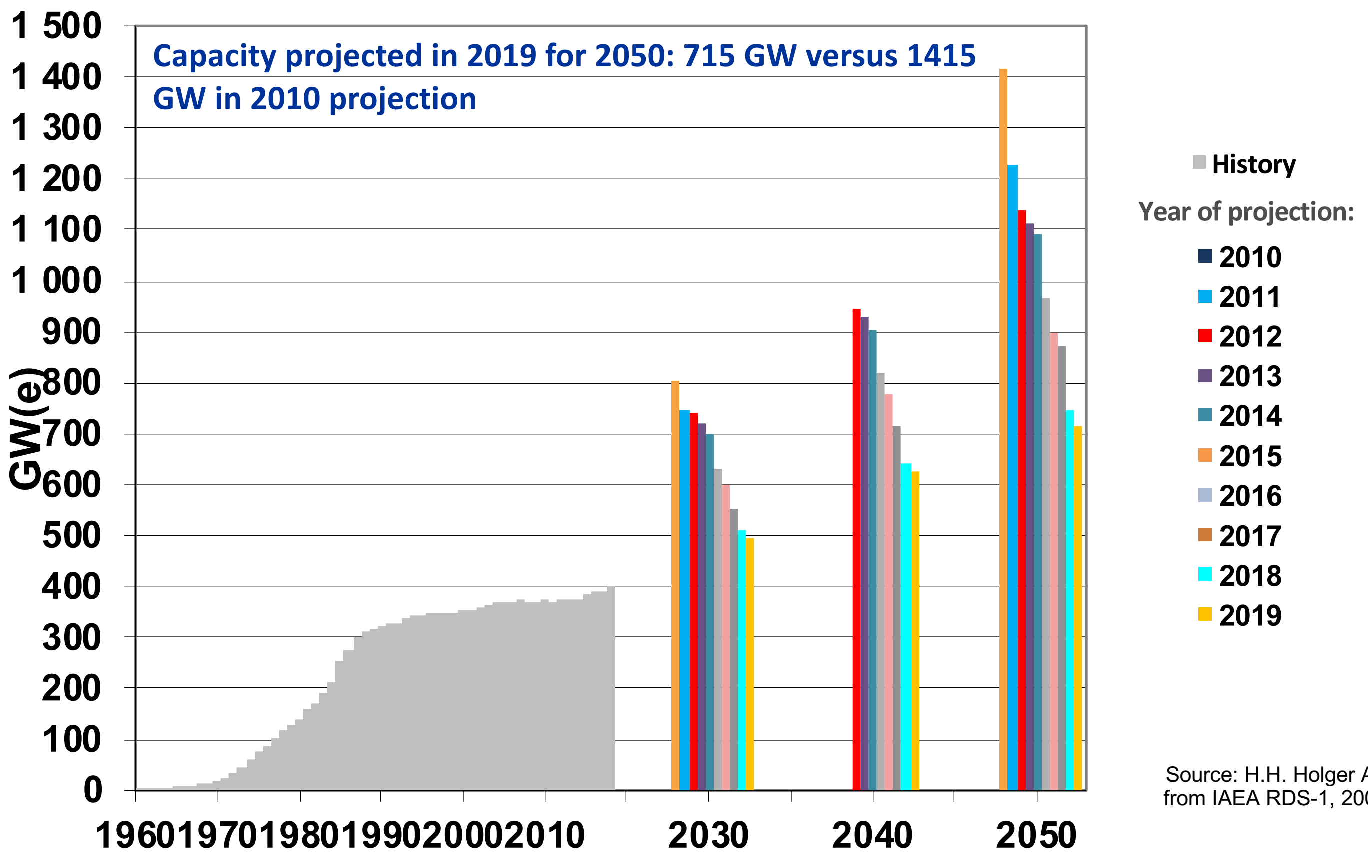
Global nuclear power projections (IEA, IAEA, WNA

- Projected installed capacity



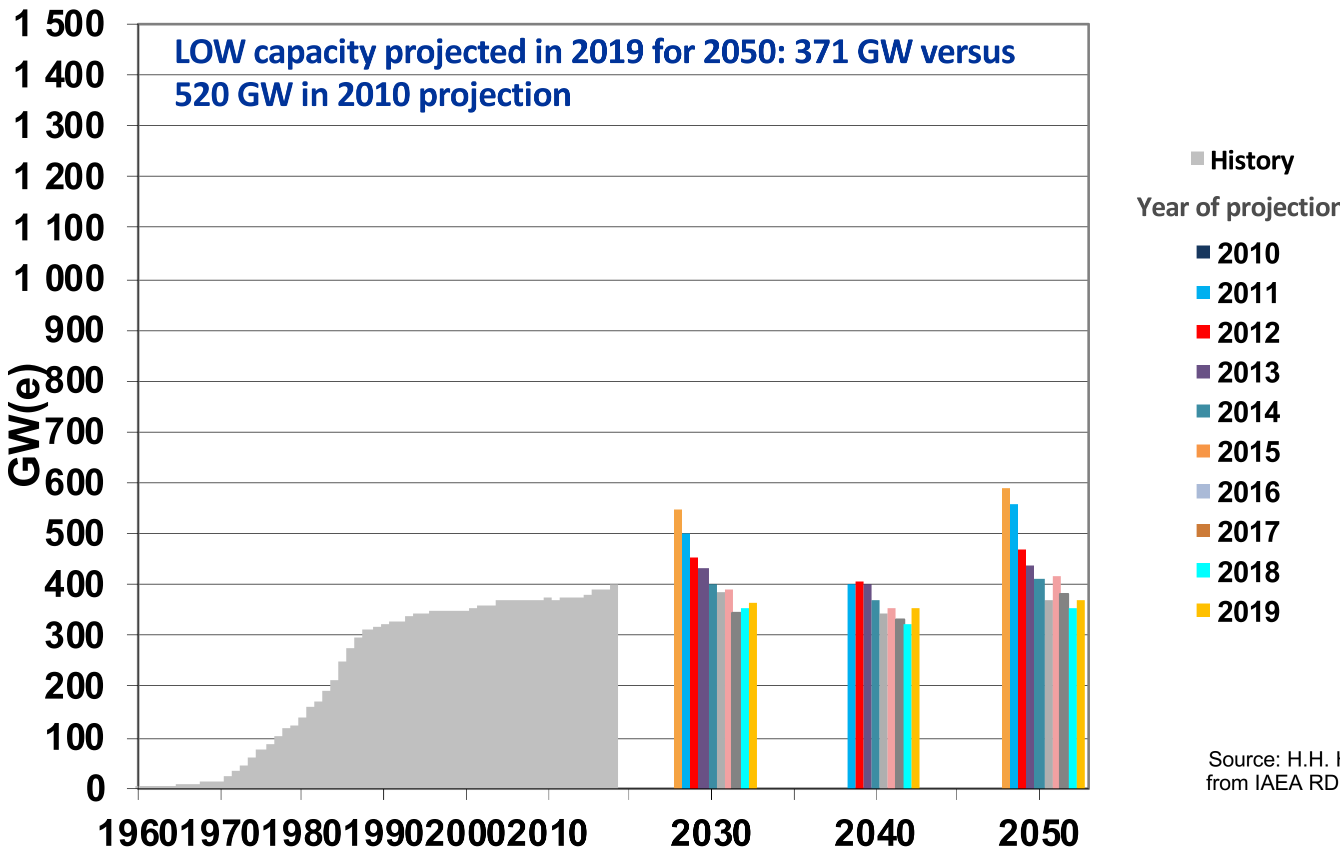
Sources: IEA, IAEA, WNA

IAEA – 2019 global nuclear capacity outlook HIGH projection



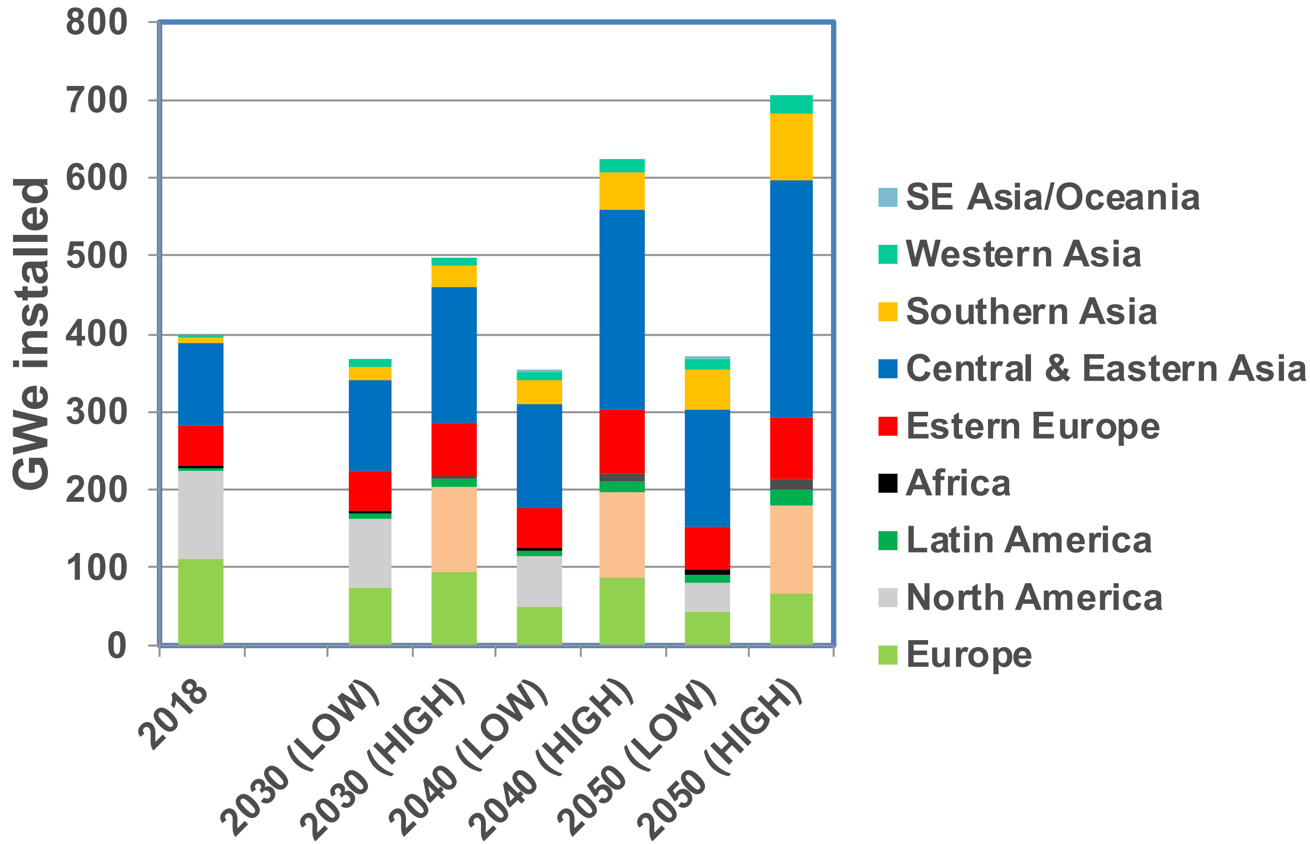
Source: H.H. Holger Adapted from IAEA RDS-1, 2005-2019

IAEA – 2019 global nuclear capacity outlook LOW projection



Source: H.H. Holger Adapted from IAEA RDS-1, 2005-2019

Electrical generating capacity, by region, GWe



Source: IAEA RDS-1, 2019

What lies behind the huge differences between low and high projections?

Increasing challenges facing newly built NPPs, from:

- **Economic competitiveness of NP is being challenged from:**
  - alternative power technologies, mainly from Renewable with rapidly falling prices, helped by favorable environment of incentives/subsidy policies, & low Gas & Coal prices, specially in OECD
  - excessive cost overruns due to regulation, GIII+ FOAK construction delays
  - Almost impossible for private business to consider new NPP projects without strong Government support, which is non existent in almost all OECD (**few exceptions like UK**)
- **Three S-Challenges/concerns remain strong head wind against expansion of Nuclear Power (In particular for new - countries):**
  - Safety: to minimize the risk of release of radioactivity from operations, accidents of NFC
  - Security; to protect and secure radioactive material and NFC facilities
  - Safeguards, (Non-proliferation): from diverting technology and material to military purpose
- **The 3-S challenges are interconnected & impact economic competitiveness; Often Safety and Security are discussed and used interchangeably**

Safety of current generation of NPP

- How likely is a large core-damage accident?
  - Core-damage frequency (CDF): a few x 10^{-5} / year
  - Probability of a large release: a few percent of CDF ≈ 10^{-6} / year
- What limits the core-damage frequency to a few x 10^{-5}/year?
- Can we do better? How?

- What could cause a given NPP to fail to achieve these safety levels?

Weak Safety Culture

- 1979: Three Mile Island (US)
  - Poor operator training
  - Insufficient sharing of information and learning from experience
- 1986: Chernobyl (USSR)
  - Top-down management created an atmosphere where a questioning attitude brought punishment
  - A weak regulatory agency – analysis not required before performing an off-normal experiment
- 2011: Fukushima (Japan)
  - Inability of safety concerns to be acted upon at higher levels within the operating company
  - Government interference with nuclear operations
  - A weak regulatory agency deferred to the operating company

Source: Bob Budnitz, Erica, Sicily, August 20, 2016

The Drivers of Nuclear Power Safety

- **Three MAIN drivers for a Nuclear Safety Centre**
  1. **Safety culture at all levels and for all stakeholders (no exemptions)**
  2. **An international nuclear safety regime which needs further strengthening (international regulator) :Examples from other fields:**
     - Civil Aviation: the ICAO Template
     - Climate Change Template (from UNFCCC to Paris Climate Agreement

  1. **Better appreciation of, and response to, the perception of risks among the public & decision makers**
- **These drivers - if not strengthened & improved, will constrain prospects of NP**
  - Nuclear safety concerns, & cost, continue to impede political & public acceptance of NP
  - Risks from potentially catastrophic accidents cannot be dealt with probabilistically in isolation nor equated to natural catastrophic events with similar risk magnitude
  - Comparative risk/benefits assessments of different generating options covering all externalities
- **Technology innovation - necessary but insufficient**
- **Perceptions matter** (cannot be changed by stating technical facts or education
  - **Including perceptions about HLW and spent fuel management**

Future expansion into "newcomer" countries:
Concerns & Prerequisites

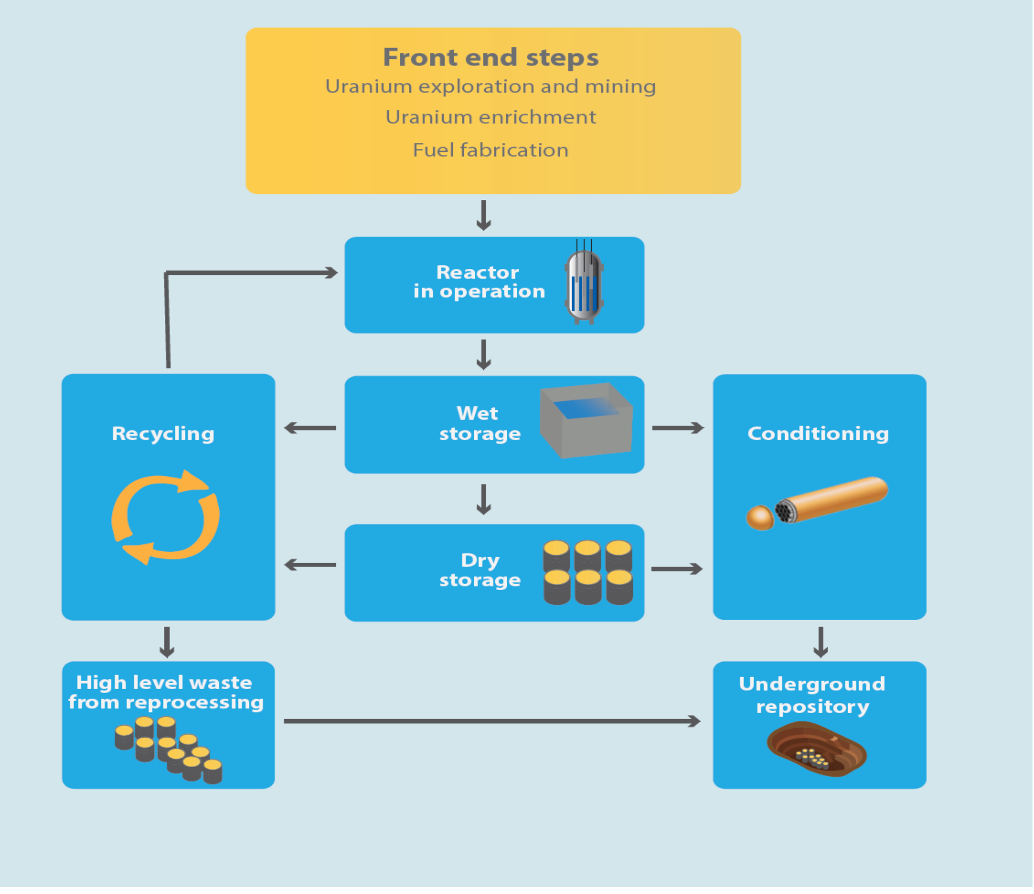
- **Safety culture is <u>the</u> major concern !**
  (… and this includes security and non-proliferation concerns too!)
- **Prerequisites:** For nuclear power to be deployed successfully in countries without a current commercial nuclear program, several cultural attributes must be present.:
  - A political culture that can make a long-term commitment,
  - provide for an independent regulatory agency with both authority & resources
  - Equally crucial are a set of social-culture issues including:
    - freedom from corruption, holding safety as paramount, a commitment to transparency in management practices and communication, and a strong continuity of institutions.
    - Public Acceptance
- Without these, a nuclear-power program is less likely to achieve an adequate safety record
- Should monitor NP development in new comer countries over 1-2 decades, UAE, Turkey, ….

Credit: Bob Budnitz, Erica, Sicily, August 20, 2016

Long Term Disposal of SF & HLW:

Nuclear power is the only large-scale energy-producing technology that is required To takes fullresponsibility for all its waste and fully costs this into the product.

- **Most nuclear utilities are required by governments to put aside a levy (e.g. 0.1 cents per kilowatt hour in the USA, 0.14 ¢/kWh in France) to provide for the management and disposal of their waste**
- **The current & future size of the problem of HLW & SF**
- **Interim & Final solutions**
- **Disposal for x000 years in underground repositories, retrievable and terminal**
- **Extensive RDD and technical solutions are feasible but NIMBY!**
- **Finland, Sweden & France most advanced with construction license submitted (granted in 2015 in FIN)**



Recent developments I (WNI, WNA, IAEA

OECD countries: Nuclear power continues to face problems on:

- **Economic grounds**
  - High upfront investments in mostly liberalized markets
  - Poor track record regarding on time and on budget construction completion
  - Massive reduction in cost of Re and continued supporting policy incentives
  - Costs of system integration of intermittent renewables externalized
  - Cheap natural gas (LNG) & shale gas in North America
  - No compensation for nuclear 24/7 capacity availability
  - No recognition of nuclear climate and other environmental benefits
  - Low growth or stagnating electricity demand
- **Rising public opposition & politics in the aftermath of FDNP accident,**
  - remaining concerns about safety of NP & lack of demonstrable progress on HLW Disposal acceptable solutions ==> affecting prospects of NP
  - ROK is latest country to announce a nuclear cap/phase-out following Germany, Switzerland, etc.
  - Other countries (e.g., France, Sweden) cap directly or indirectly market share of nuclear power
  - Phase-out politics frustrate NPP staff and potentially could affect nuclear operating safety
- **Knowledge depreciation**
- **Only UK, Poland, Chec, France, Finland, few others remain viable for now**

Recent developments II (WNI, WNA, IAEA, ..

- **Non-OECD Countries**
  - **Prospects remain relatively bright in Asia and newcomer countries**
    - In addition to China, India, Pakistan, Russian Federation, several Latin American, African and Middle Eastern Countries (e.g. UAE, KSA, Iran, Egypt, Turkey)
  - Nonetheless, public apprehension and signs of organized opposition is also becoming visible and rising in developing economies (within ongoing programs and new comers) – **Future of NP dependent on China & India, and Russia**
- **Waste: World 1st permanent HLW Waste repository received construction permit! (FIN), Good step but Jury will take a long time, as we need more examples of such technology solutions**

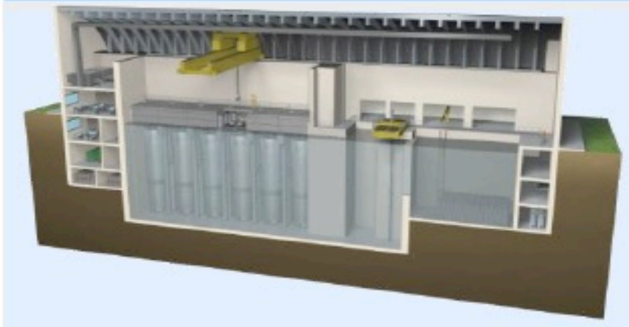
Would Climate change challenge bring renewed interest in Nuclear Power, in particular small modular reactors (SMRs) – the new lease on life for nuclear power! For now "All Renewable" overshadowing potential roles of Nuclear & Decarbonized O&G

Will SMRs save the day?

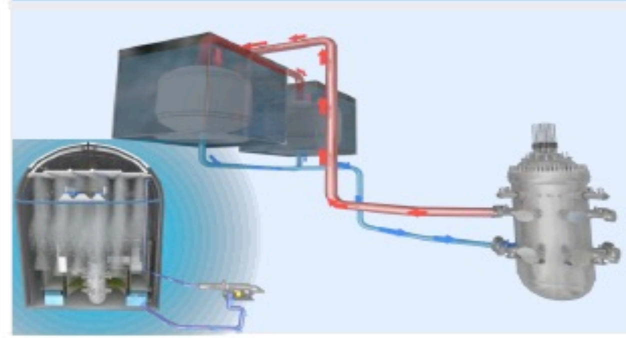
Drivers & Expected Advantages

Driving Forces for SMRs

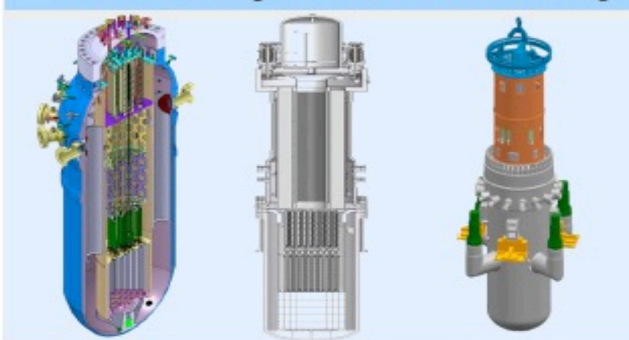
Scalability of Power



Enhanced Safety



Modularity, Constructability



Flexibility of Utilization

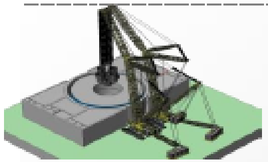
Images courtesy of US-DOE, NuScale, KAERI, CNEA, mPower & CNNC

Key expected advantages

IAEA 60 Years
Atoms for Peace and Development

Economic
- Lower Upfront capital cost
- Economy of serial production

Better Affordability



Modularization
- Multi-module
- Modular Construction

Shorter construction time

Flexible Application
- Remote regions
- Small grids

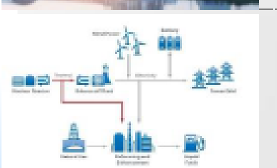
Wider range of Users

Smaller footprint
- Reduced Emergency planning zone

Site flexibility

Replacement for aging fossil-fired plants

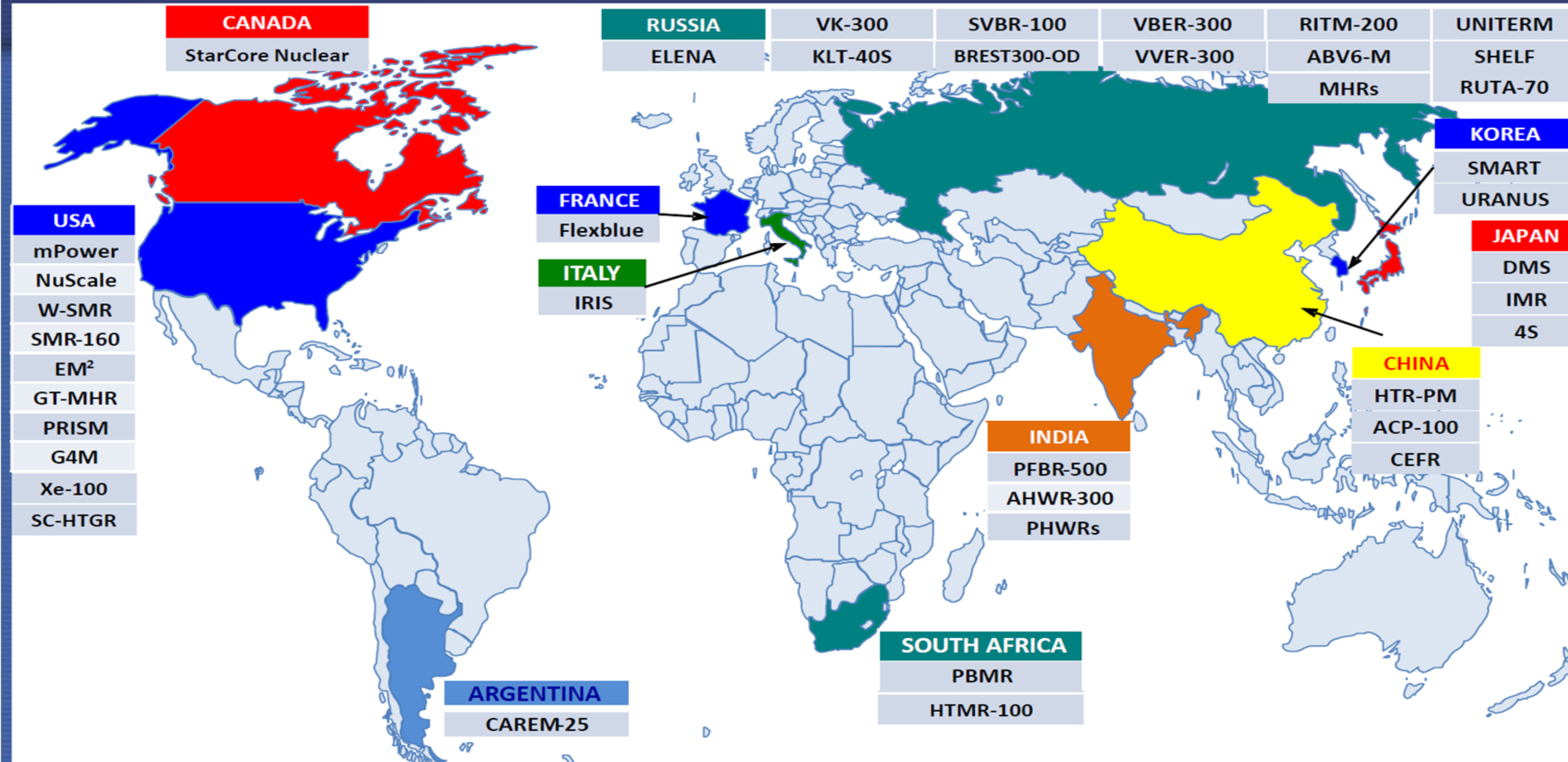
Reduced CO_2 production



Potential Hybrid Energy System

Integration with Renewables

Map of Global SMR Technology Development



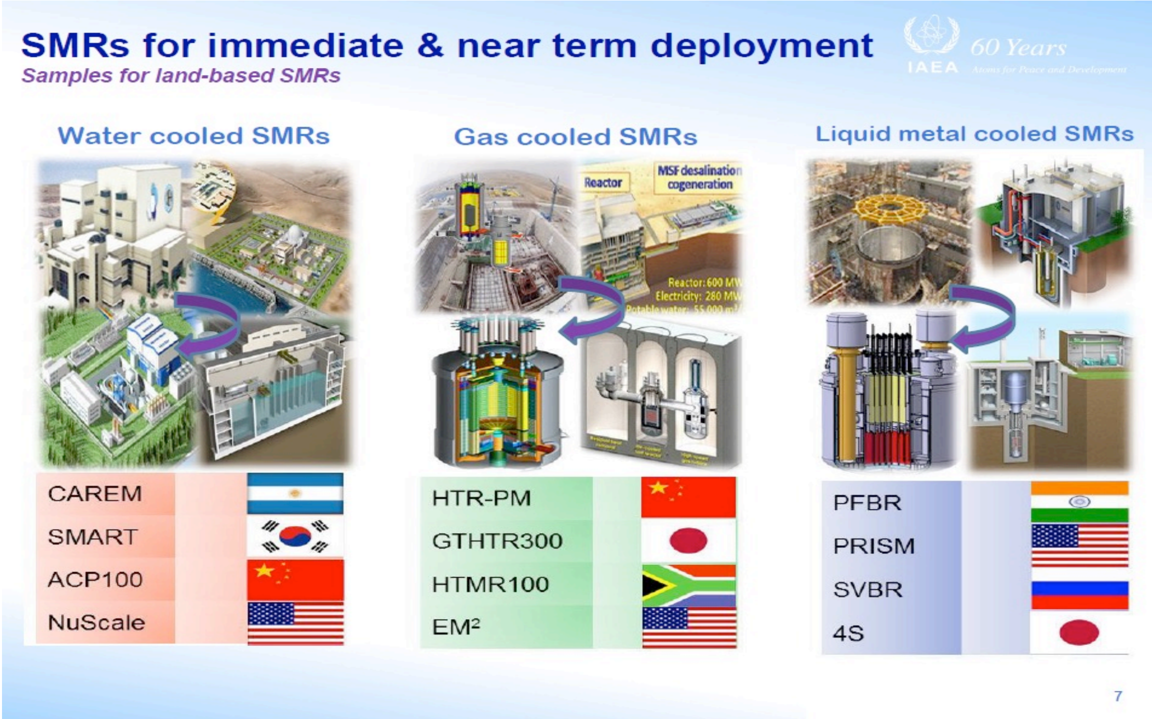
IAEA

About 40 SMR design teams world-wide

SMRs Under Construction Now

- About 40 SMR design teams world-wide working on:
  - Evolutionary
  - Revolutionary
- Under Construction Now
  - Argentina:
    - 27 MWe integral PWR
  - China
    - 105 MWe pebble bed high temperature gas reactor
  - Russia
    - 70 MWe integral PWR (ship)
    - 50 MWe integral PWR (icebreaker)

- Design Types for immediate & Near Term Deployment



SMRs Estimated Timeline of Deployment

IAEA 60 Years Atoms for Peace and Development

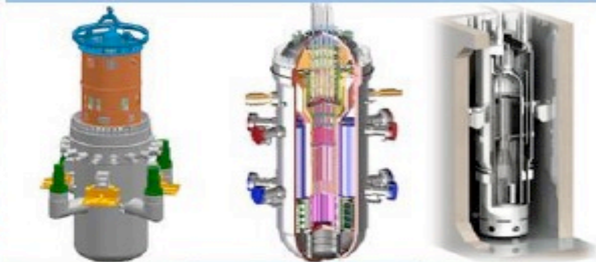
Immediate Deployable

CAREM	HTR-PM	KLT-40S
Argentina	China	Russian Federation

Under Construction

- **CAREM-25**
  CNEA, Argentina
- **KLT-40S**
  OKBM Afrikantov, Russian Federation
- **HTR-PM**
  INET, China

Near-term Deployable

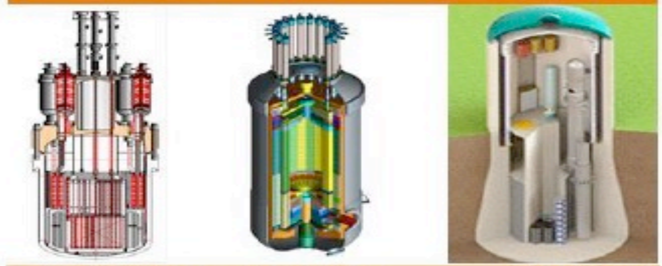


ACP100	SMART	NuScale
China	Republic of Korea	USA

Certified or at Advanced Design Stage

- **SMART**
  KAERI, Republic of Korea
- **RITM-200**
  OKBM, Russia
- **PRISM**
  GE-Hitachi, USA
- **PBMR-400**
  PBMR, South Africa
- **BREST300-OD**
  NIKIET, Russia
- **4S**
  Toshiba, Japan
- **ACP100**
  CNNC, China
- **NuScale**
  NuScale Power, USA
- **mPower**
  B&W, USA
- **GTHTR300**
  JAEA, Japan
- **SVBR-100**
  AKME Engineering, Russia
- **ABV-6M**
  OKBM, Russia

Mid to Longer-term Deployable

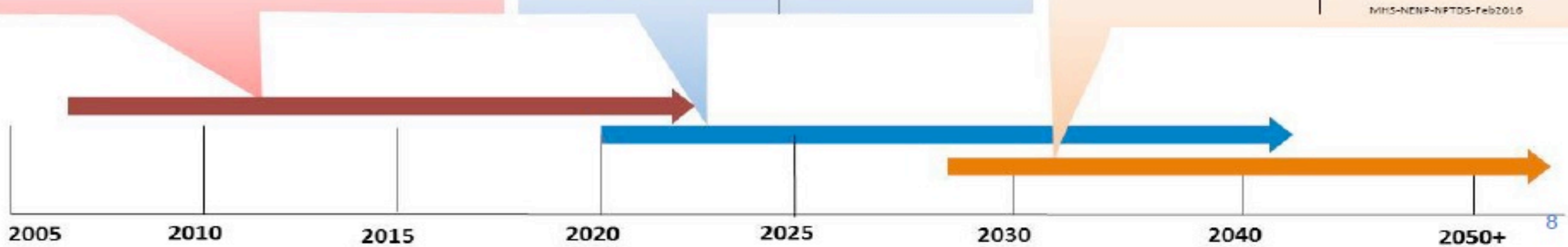


UNITHERM	HTMR100	SMR160
Russian Federation	South Africa	United States of America

Conceptual Design for Future Deployment

- **AHWR300**
  BARC, India
- **Flexblue**
  DCNS, France
- **IRIS**
  IRIS International Consortium
- **DMS**
  Hitachi-GE, Japan
- **IMR**
  MHI, Japan
- **VVER-300**
  OKB Gidropress, Russia
- **Westinghouse SMR**
  Westinghouse, USA
- **SMR160**
  Holtec, USA
- **VK-300**
  NIKIET, Russia
- **Th-100**
  STL, South Africa
- **SC-HTGR**
  AREVA, France
- **G4M**
  Gen4 Energy, USA

MHS-NENP-NPTDS-Feb2016



Power Range of SMRs

Power Range MW(e)	Reactor Designs
> 301	IMR, AHWR-300, VBER-300, GTHTR300, IRIS
251-300	DMS, GT-MHR, EM², BREST-OD-300, SC-HTGR
201-250	Westinghouse SMR, FUJI, MHR-T, ThorCon, LFTR
151-200	mPower, SMR-160, PBMR-400, IMSR, Flexblue
101-150	CAP150, HTR-PM, MSTW, Mk1 PB-FHR, SmAHTR
51-100	ACP100, SMART, MHR-100, SVBR100, ACPR50S
0-50	CAREM25, NuScale, KLT-40S, HTMR-100, G4M

Power Range MW(e)

Reactor Designs

Concluding Remarks

- **Nuclear Power continues to face challenges (3S); very likely to continue slow growth– @ significantly reduced rate for next 10 years at leas; Mostly outside OECD – in Asia**
- **NP is complex technology. NO technology is w/o risks, but without new approach, it will be difficult to convince public to accept relative benefits far outweigh perceived risk;**
- **Phasing out NP in OECD is political GAMBIT!; It may be a mistake, but OECD can afford it**
- **Dim outlook in OECD, with head wind from euphoric-support embracing all Re electricity**
- **For NP to make a major contribution to mitigation of climate change and meeting SD goal 7, it must overcome rising aversion to NP:**
  - prove economic competitiveness of some G III+, G-IV & SMR, under market, & local environments
  - demonstrate practical solutions to HLW disposal (Finland, Sweden, France,..)
  - strengthen nuclear safety, all levels, including culture and the international safety regime,
  - develop effective strategies to improve public and decision makers' understanding of benefits vs. perception of associated risks,
  - Resolve the obstacles to full implementation of NPT, including start of disarmament of all NWS, INFCCs..
- **G-IV, SMR (Revolutionary) nuclear technologies offer a possible path for bright future**

○ **Would nuclear fusion finally turn the corner, with ITER? In 2 decades?**