Tackling Indonesia's Nuclear Power Euphoria

How to Reconcile Nuclear's Technical Promise With Market Realities

ELRIKA HAMDI, Energy Finance Analyst

June 2021

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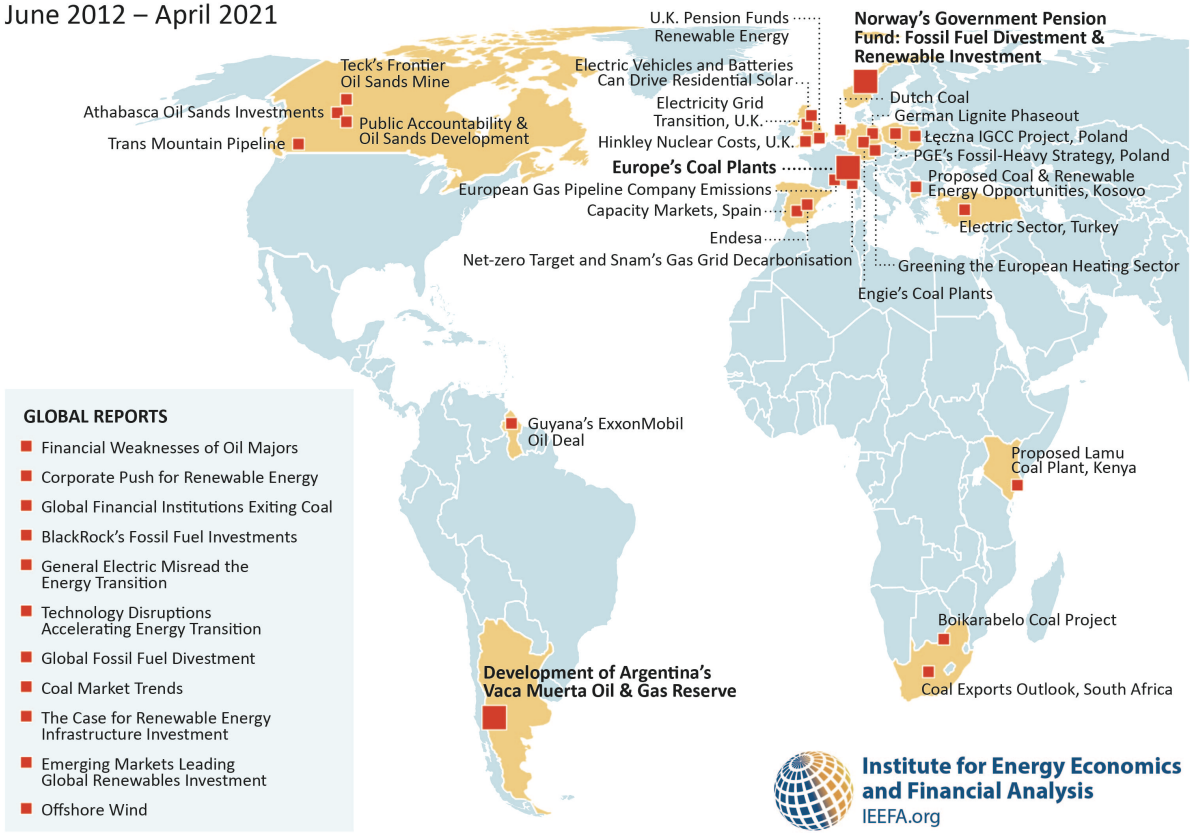

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- Financial Weaknesses of Oil Majors
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- Global Financial Institutions Exiting Coal
- BlackRock's Fossil Fuel Investments
- General Electric Misread the Energy Transition
- Technology Disruptions Accelerating Energy Transition
- Global Fossil Fuel Divestment
- Coal Market Trends
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- Offshore Wind

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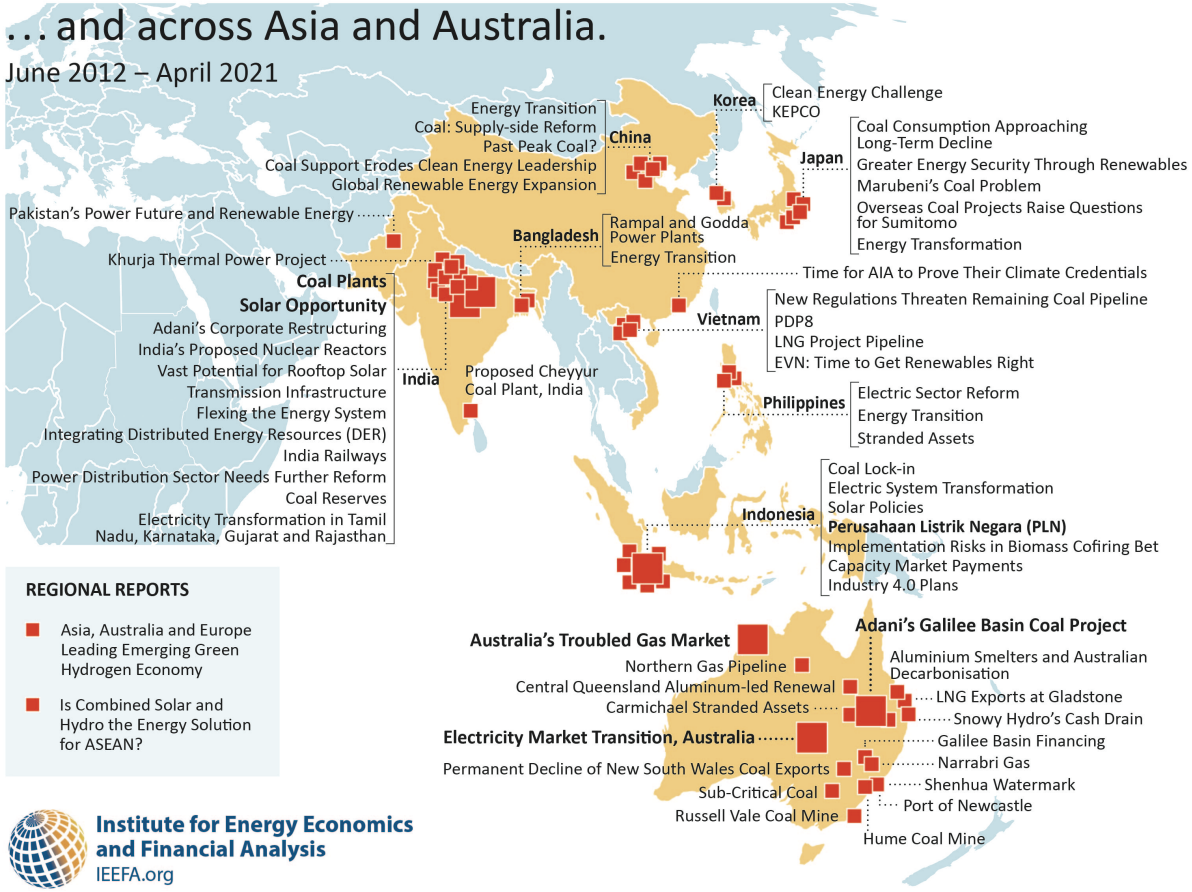

REGIONAL REPORTS

- Asia, Australia and Europe Leading Emerging Green Hydrogen Economy
- Is Combined Solar and Hydro the Energy Solution for ASEAN?

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Intense Media Coverage on Nuclear

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Thorcon, Defense Ministry to cooperate on thorium nuclear reactor

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Wacana Pembangkit Nuklir di Indonesia, PLN : Kami Masih Monitor

PT PLN (Persero) mengatakan hingga saat ini belum mengambil keputusan terkait pengembangan pembangkit listrik tenaga nuklir (PLTN).

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BERANDA PROFIL NASIONAL RAGAM LAYANAN BERITA GALERI LAPOR!

Ilustrasi PLTN. Foto: Int/Istimewa

Thorium, Harapan Baru Indon...

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Indonesia membutuhkan pembangkit lis...

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NEWS BISNIS BO...

Cek Fakta

...sia Butuh

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...orium

...uranium, atau yang

...juga sebenarnya sudah lama menjadi bahan

...ggunaan nuklir selalu yang dikemukakan adalah untuk

...engan bahan baku uranium.

...h mengungkapkan Indonesia berencana membangun

...an energi guna memenuhi kebutuhan listrik sebanyak

...uria, Kudus, Jawa Tengah, Bangka Belitung, atau di

...ari uranium. Indonesia sendiri sebenarnya sudah memiliki

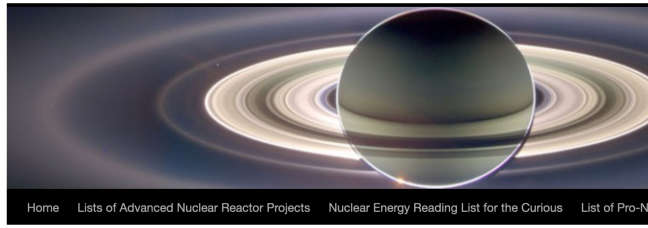
...nembangun reaktor nuklir terbaru atau yang ke-4 di

...dan beroperasi 2019 tersebut juga akan menggunakan

...s 30 MW. Kombinasi reaktor ini bisa uranium, juga

Jakarta, CNBC Indor...

Neutron Bytes



Home Lists of Advanced Nuclear Reactor Projects Nuclear Energy Reading List for the Curious List of Pro-N...

← US Agency to Fund Nuclear Energy Exports

Letter to Editor at NYT about UAE Nuclear Energy Program →

ThorCon Inks MOU to Develop a 50MW Thorium Reactor for Indonesia

Posted on August 1, 2020 by djysrv

- ThorCon to Develop 50MW Thorium Fueled Reactor in Indonesia Leading to 500MW Units Built in Shipyards.
- Rosatom Pitches Indonesia for Conventional Light Water Reactors
- CEZ Signs Framework Deal with Czech Govt for New Nuclear Unit

ThorCon to Develop 50MW Thorium Fueled Reactor for Indonesia

Institute for Energy Economics and Financial Analysis
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What about in South East Asia?

Nuclear plan is indefinitely postponed

Ongoing debates to revive their long-built-but-never-commissioned 621MW nuclear plant

Or

To build a new one from ground up

Trending topic

SMR nuclear power plants (by ThorCon)

And

Big scale nuclear plants studies (Muria, Bangka Belitung, Kalbar)

A deep and honest discussion about the role of nuclear power in Indonesia

TECHNICAL VIABILITY

≠

ECONOMIC & FINANCIAL VIABILITY

≠

MARKET VIABILITY

Three Fundamental Challenges

TECHNICAL VIABILITY

Types of Nuclear Reactors

Operable Nuclear Power Reactors at Year-End 2019

	Boiling water reactor	Fast neutron reactor	Gas-cooled reactor	Light water graphite-moderated reactor	Pressurized heavy water reactor	Pressurized water reactor	**Total**
Africa						2	**2**
South America					3	2	**5**
Eastern Europe and Russia		2		13		38	**53**
North America	34				19	64	**117**
Western and Central Europe	10		14		2	102	**128**
Asia	21				24	92	**137**
Total	**65**	**2**	**14**	**13**	**48**	**300**	**442**

Source: World Nuclear Performance Report 2020

PWR dominates, **BWR** comes second – both are **LWR**s.

Meanwhile **only 1 SMR currently operating** - 70 MW Akademik-Lomonosov in Russia.

Safety, security and safeguard remains the biggest challenge

A Non-Exhaustive List of Publicly Acknowledged Accidents or Serious Incidents Resulting in Nuclear Reactor Shutdowns

Country	Reactor	Type	MWe Net	Years Operable	Shutdown
Germany	Greifwald 5	VVER-440/-213	408	0,5	11/1989
Germany	Gundremmingen A	BWR	237	10	01/1977
Japan	Fukushima Daiichi 1	BWR	439	40	03/2011
Japan	Fukushima Daiichi 2	BWR	760	37	03/2011
Japan	Fukushima Daiichi 3	BWR	760	35	03/2011
Japan	Fukushima Daiichi 4	BWR	760	32	03/2011
Japan	Monju	Prot FNR	246	1	2016
Slovakia	Bohunice A1	Prot GCHWR	93	4	1977
Spain	Vandellos 1	GCR	480	18	mid-1990
Switzerland	St Lucens	Exp GCHWR	6	3	1966
Ukraine	Chernobyl 4	RBMK LWGR	925	2	04/1986
USA	Three Mile Island 2	PWR	880	1	03/1979

Based on the current installed capacity of 440 active reactors globally, a major disaster might happen once every 10 to 20 years.

Safety, security and safeguard remains the biggest challenge

Nuclear accidents

Three Mile Island

Cost **US$ 1 billion** for 14 years

Chernobyl

Cost **US$ 700 billion** for 30 years

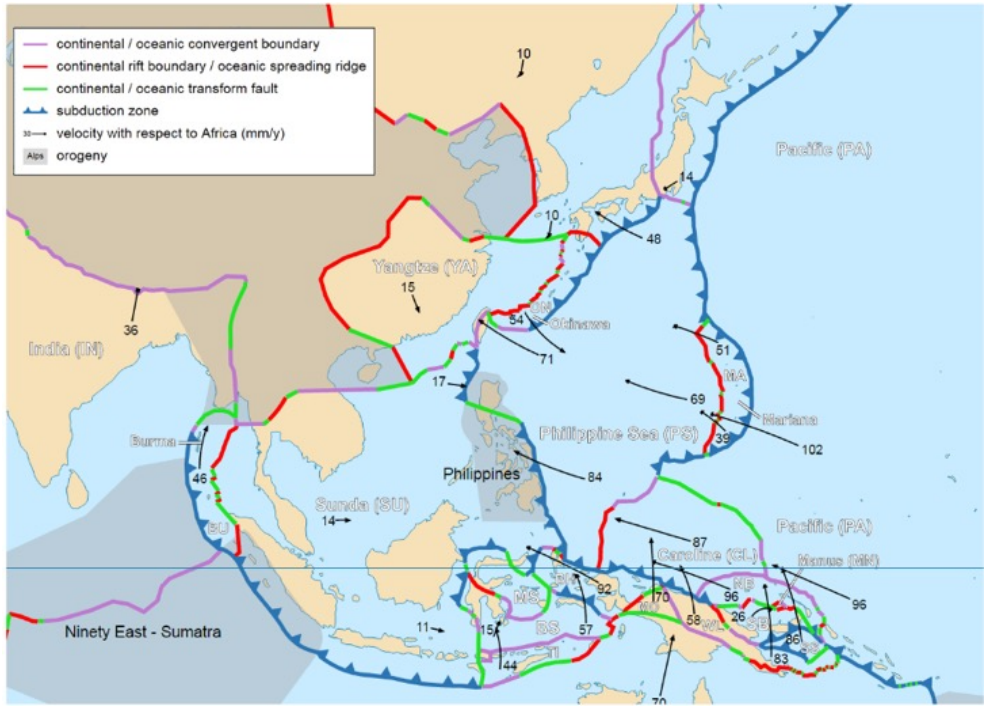
Fukushima

Cost **US$ 200 billion** for 30 years

These accidents have taken place **<u>despite the fact</u>** that the nuclear industry has been subject to high-level governance and oversight at global and country levels

Geography and Geology

Tectonic Plates in Southeast Asia



SEA region:

- **RING OF FIRE** = seismic risk
- 452 volcanoes – 28% are active
- SEA is home to 90% of the world's earthquakes

Indonesia

- 127 active volcanoes
- 5,000 – 6,000 earthquakes every year
- At least 10 tsunamis
- Increasing numbers of massive floods due to climate change
- Risk of forest fires

The risks associated with geological instability needs to be assessed not only for operational safety, but also for the safe disposal of nuclear waste

The Legacy Nuclear Waste Disposal Issue

Solid Radioactive Waste in Storage (m3), as of 31 December 2013

	VLLW	LLW	ILW	HLW
Africa	7,000	20,000	1,000	-
Eastern Europe	15,000	2,479,000	101,000	7,000
Western Europe	224,000	355,000	269,000	6,000
Far East	5,000	331,000	4,000	-
North America	2,105,000	248,000	84,000	8,000
Latin America	-	37,000	-	-
Middle East and South Asia	-	3,000	-	-
South East Asia and Pacific	-	5,000	1,000	-
Global Total	**2,356,000**	**3,478,000**	**460,000**	**22,000**

No country has found a workable, economically viable permanent solution for nuclear waste disposal.

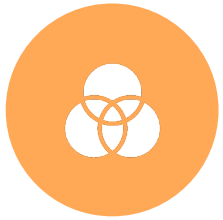
Finland is the closest with the Olkiluoto deep repository site, 400 m deep in a 2-billion-year-old igneous rock. Currently still under construction.

The Legacy Nuclear Waste Disposal Issue

What has been done so far by nuclear countries?

Storage

In storage pools or dry casks
Some dry casks have started leaking toxic waste



Reprocess

To recover residual uranium and plutonium from spent fuel – in a closed fuel cycle
14% more expensive

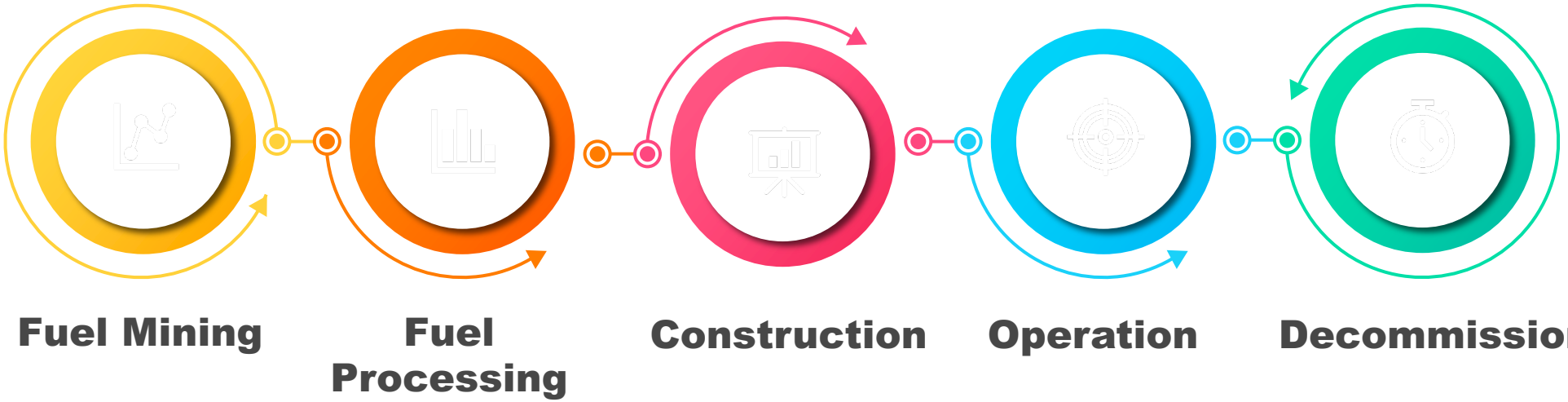
Awaiting

With risks including technological malfunction, natural disaster, end-of-life costs, and terrorist attacks

Question for Indonesian policymakers:
Is there any stable geological structure several hundred meters below ground that exists in Indonesia?

Greenhouse Gas Emissions From Nuclear Power Plants May Be Comparable to Hydro and Wind Power, but Nuclear Still Comes With Radiological Risk

Life Cycle Analysis to Calculate GHG



For nuclear, the emissions appear mostly during fuel mining and processing, during operation, and spent fuel reprocessing

Greenhouse Gas Emissions From Nuclear Power Plants May Be Comparable to Hydro and Wind Power, but Nuclear Still Comes With Radiological Risk

Life Cycle Assessment of Power Generation Technologies

Technology	Lifecycle Emission kg CO^2e/MWh
Hard coal	660-1050
Lignite coal	800 – 1300
Natural gas	380 - 1000
Oil	530 – 900
Biomass	8.5 - 130
Hydropower	2-20
Solar energy	13 - 190
Wind	3 - 41
Nuclear (Turconi, Boldrin & Astrup)	3-35
Nuclear (Benjamin K. Sovacool)	1.4 - 288

Sources: Renewable and Sustainable Energy Reviews 2013. Turconi, R., Boldrin, A., & Astrup, T.

GHG of nuclear may be comparable with hydro and wind

BUT

It still comes with radiological risk that other renewable sources do not have!

New Gen-IV Technology – a Work in Progress

Supporter VS Opponents

Smaller & modular

Easily deployed, increase construction efficiency, reduce capital costs.

Faster construction time

Can be built off-site and shipped to site.

Safer technology

Self-contained reactors, can shut itself down, remain cool for an unlimited time.

New & untested

Require long & rigorous oversights – high risk on construction delays

Unproven claim for safety & cost issues

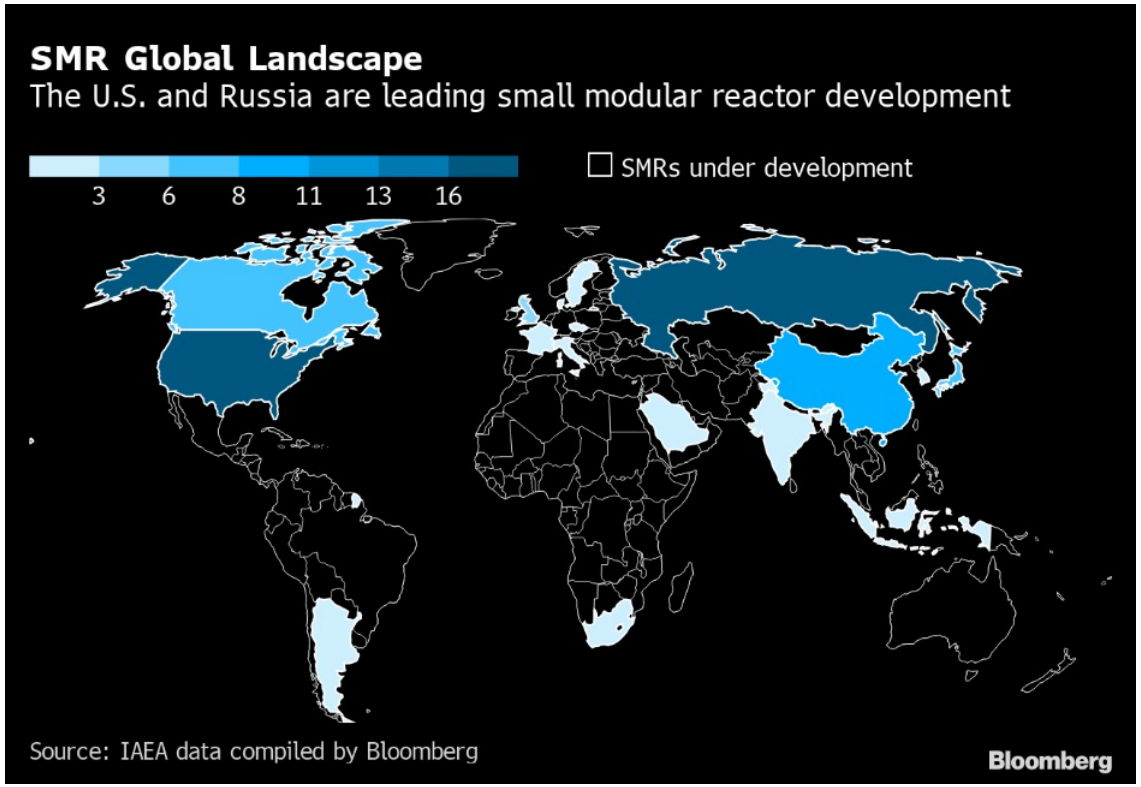
Economic of scale will be limited due to each reactor needing its own control & safety system. This will increase costs.

Still carry unresolved waste issue

The SMR technology still produces high-level long-lived radioactive waste

New Gen-IV Technology – a Work in Progress

SMR Global Landscape led by the US and Russia



Sources: Bloombers

NuScale Power is the closest to bringing the SMR technology across the finish line.

- ✓ Backed by Fluor Corp, a major US EPC company
- ✓ Design certification submitted in 2017, and still not yet certified by the US NRC
- ✓ Estimated cost has ballooned from US$ 3 billion in 2015 to US$ 6.1 billion in 2020.
- ✓ Relies upon subsidies from the US taxpayers

How about ThorCon?

Reliability of Fuel Supply

World Uranium Resources

Countries	Tonnes	% of the World
Australia	1,818,300	30%
Kazakhstan	842,200	14%
Canada	514,400	8%
Russia	485,600	8%
Namibia	442,100	7%
South Africa	322,400	5%
China	290,400	5%
Niger	280,000	5%
Brazil	276,800	5%
Uzbekistan	139,200	2%

Source: World Nuclear Association

World Thorium Resources

Countries	Tonnes	% of the World
India	846,000	13.3%
Brazil	632,000	9.9%
Australia	595,000	9.3%
USA	595,000	9.3%
Egypt	380,000	5.9%
Turkey	374,000	5.8%
Venezuela	300,000	4.7%
Canada	172,000	2.7%
Russia	155,000	2.4%
South Africa	148,000	2.3%

Three Fundamental Challenges

ECONOMIC AND FINANCIAL VIABILITY

The Complex Nature of Nuclear Power Drives Upside Cost Risks

A. Inaccurate Cost Estimate

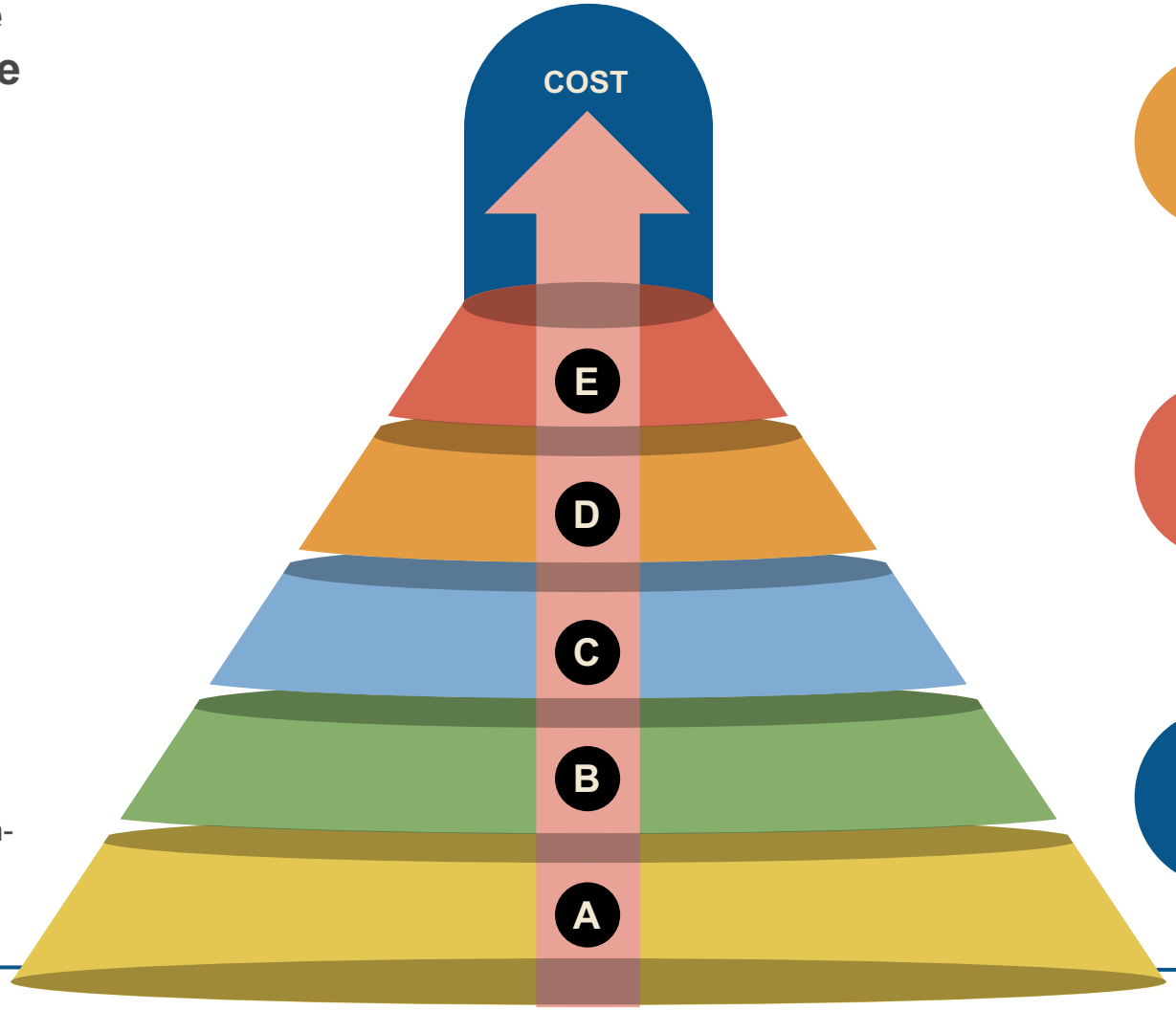
Underestimating construction time schedule.

B. Human Resources

Specific design requirements need highly qualified specialists

C. Strict Licensing

Longer time needed, especially for the non-standardized design



D. Strict Safety Regulations

Sometimes require additional passive-control system, high insurance premium, and additional security measures

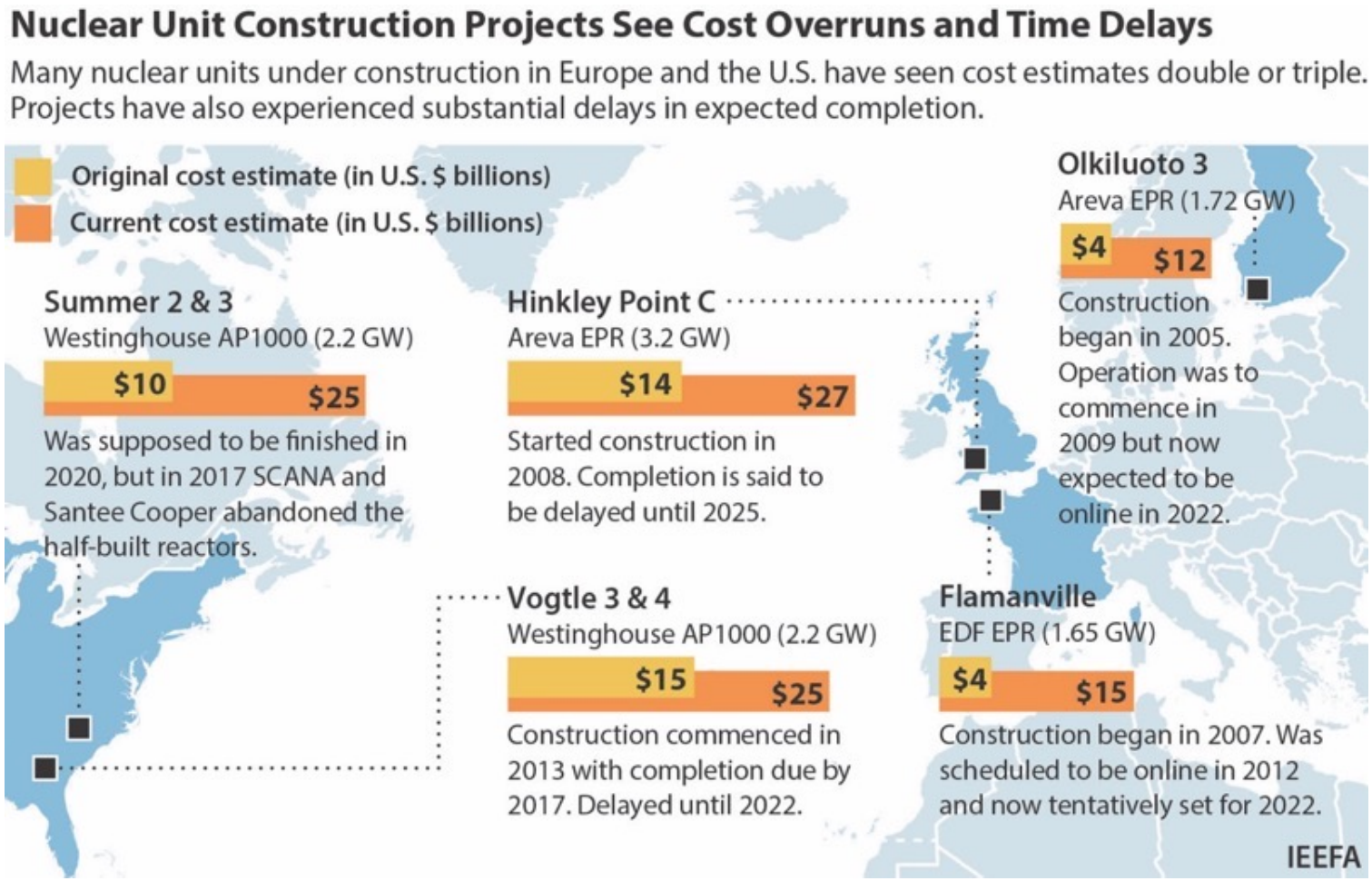
E. Compounding Financing Cost

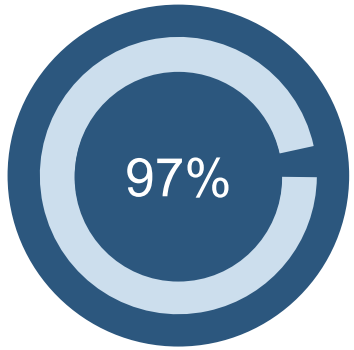
As a result of construction delays.

F. Political and Regulatory Risks

Untimely & expensive, especially in countries with inconsistent policies.

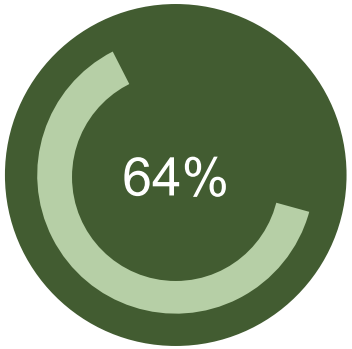
The Complex Nature of Nuclear Power Drives Upside Cost Risks





175 out of 180 projects

Average US$ 1.3 billion cost overruns **per project**

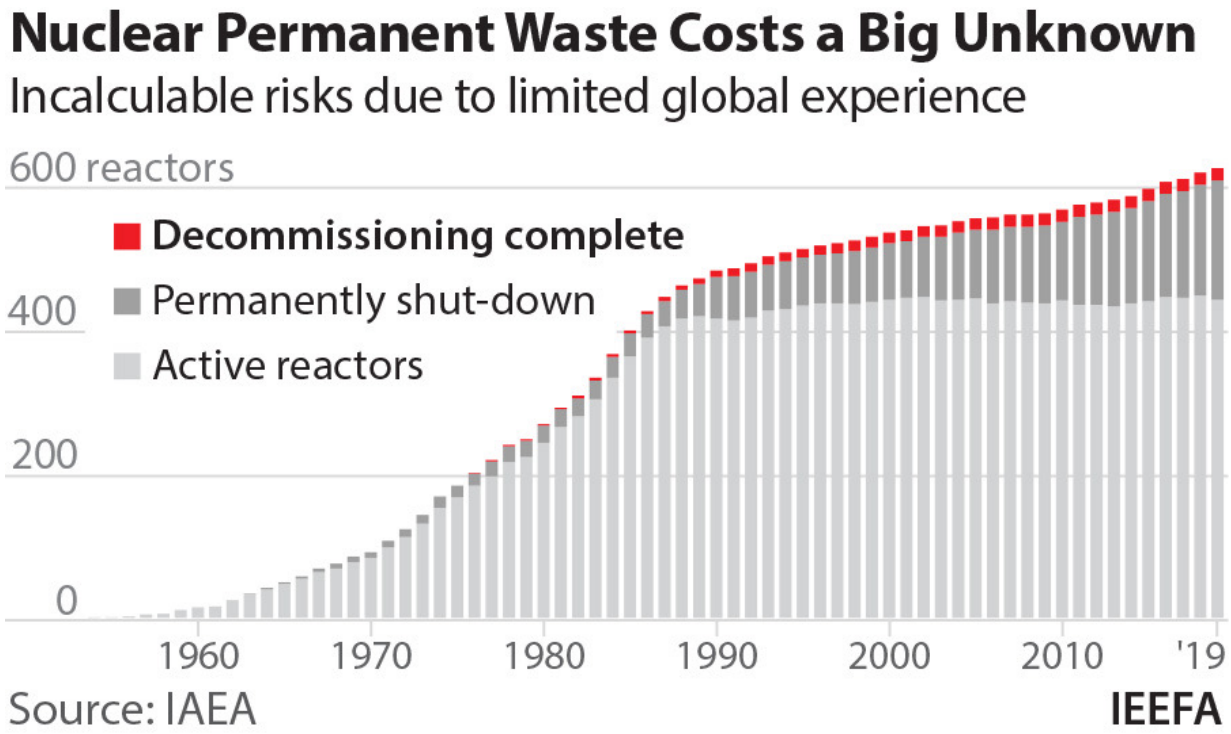


More time in construction

The Complex Nature of Nuclear Power Drives Upside Cost Risks

Don’t forget the growing cost of insurance!

The Cost of Decommissioning and Nuclear Waste Disposal is still a Mystery



Globally, **only 20 units out of 189 reactors have been fully decommissioned**

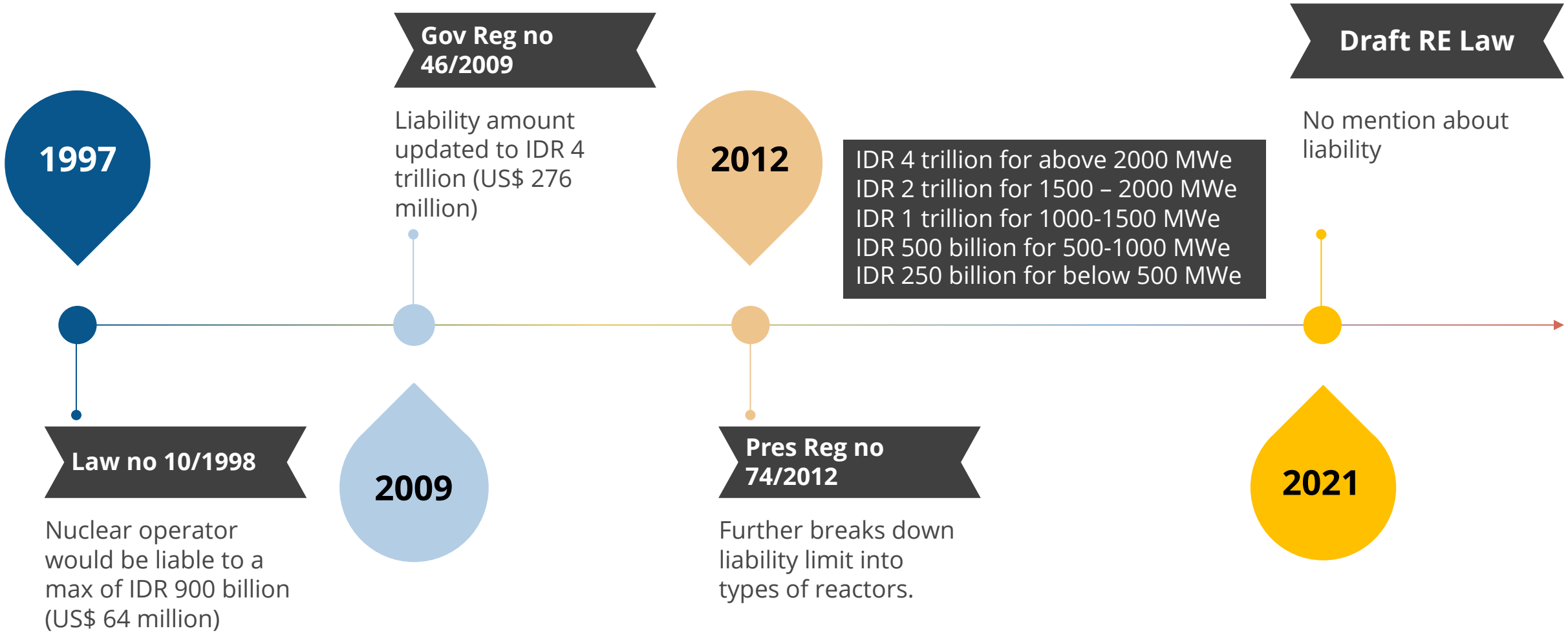
Cost of decommissioning:

- **France** – EDF estimates the need for €79.4 billion in 2012. By 2016, EDF has set aside €36 billion.
- **Germany** sets aside €23.6 billion for interim storage, €38 billion for decommissioning 17 reactors

Cost of permanent waste disposal:

- **Finland** - US$ 555 million for construction of Olkiluoto, and US$ 3.9 billion to operate for 100 years
- **US** – at least US$ 6 billion to address the high-level waste from the Manhattan Project

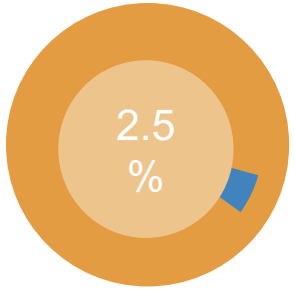
Indonesian Regulation on Nuclear Accident Liability – comes with Caveats



Three Fundamental Challenges

MARKET VIABILITY

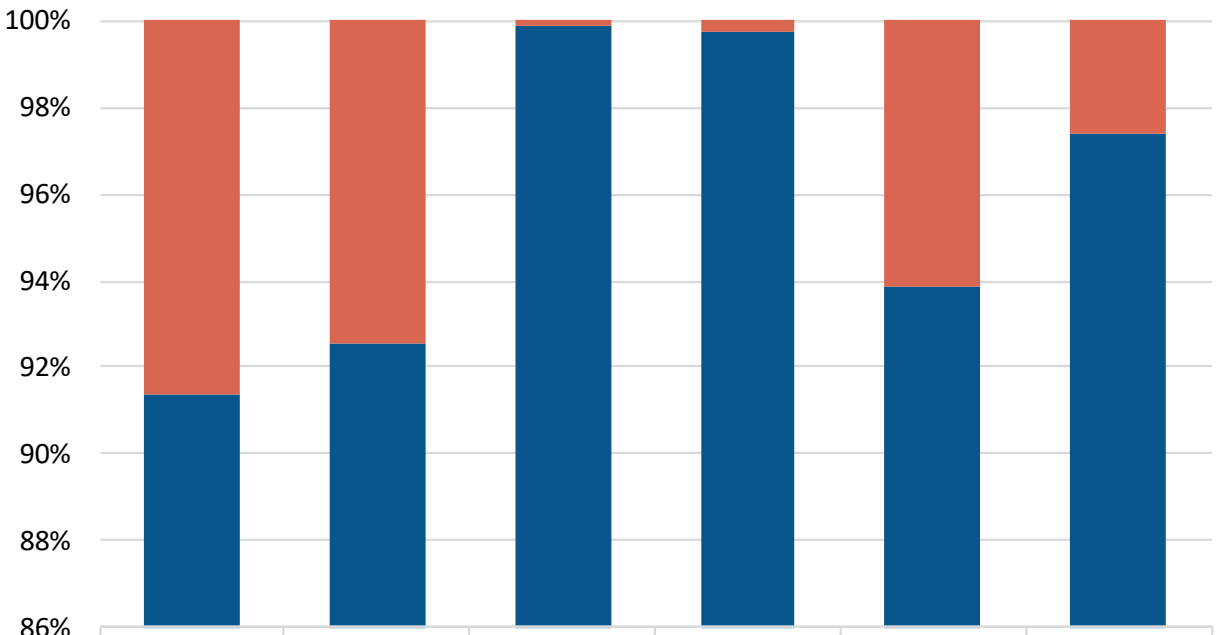
Competition from Renewables



Of RE potential have been utilized

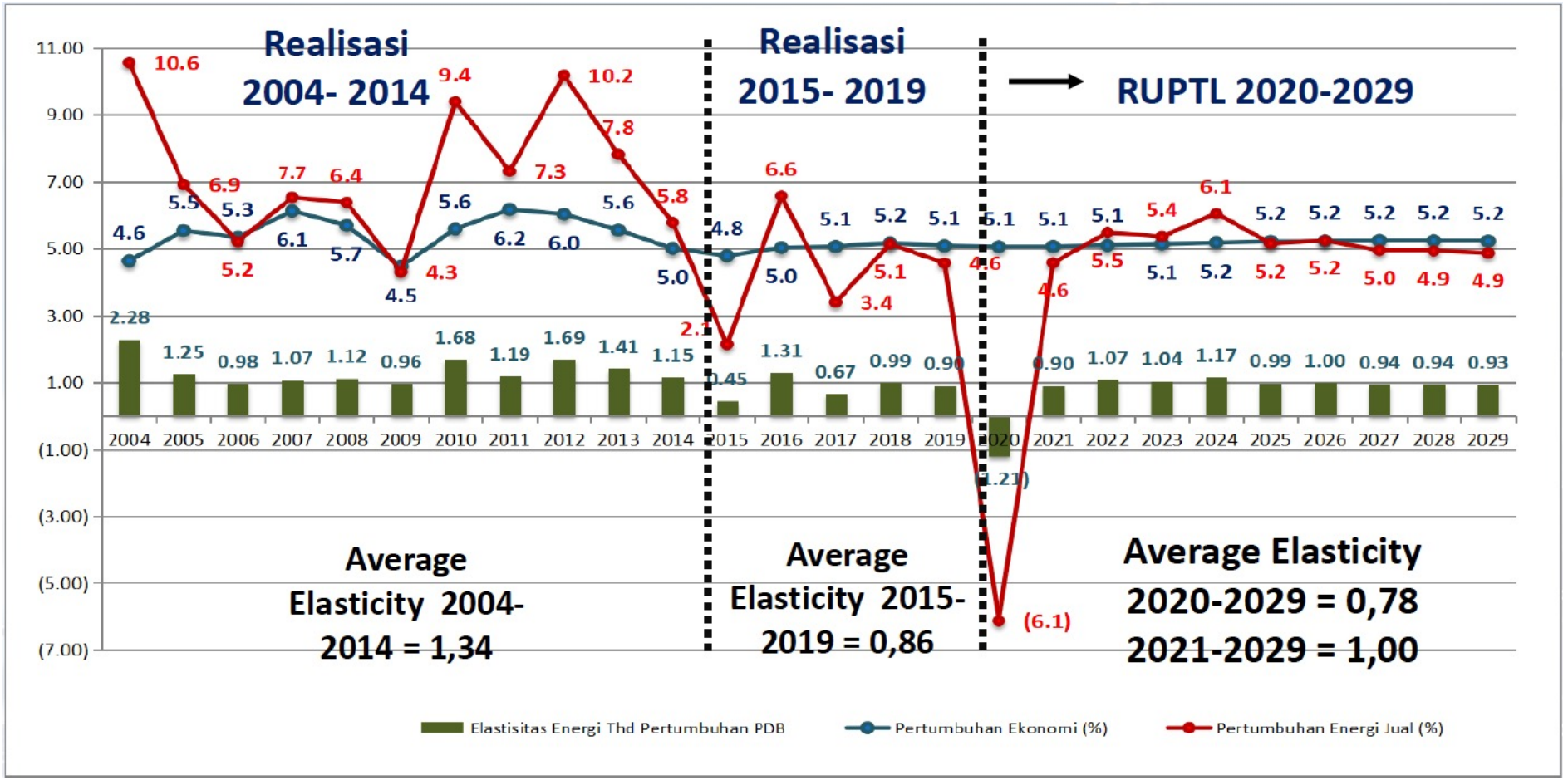
Nuclear has to compete with:

- Mature technology like hydro
- Technical knowledge & golden site of hydro
- Declining cost curves of solar & wind & storage
- Gov-backed geothermal exploration
- PLN push for biomass cofiring
- New unexplored potential: off-shore wind & ocean power



	Geothermal	Hydro	Solar	Wind	Bioenergy	Total
Current Installed Capacity (MW)	2,271	6,051	232	154	2,132	10,839
Potential (MW)	23,966	75,091	207,898	60,647	32,654	400,256

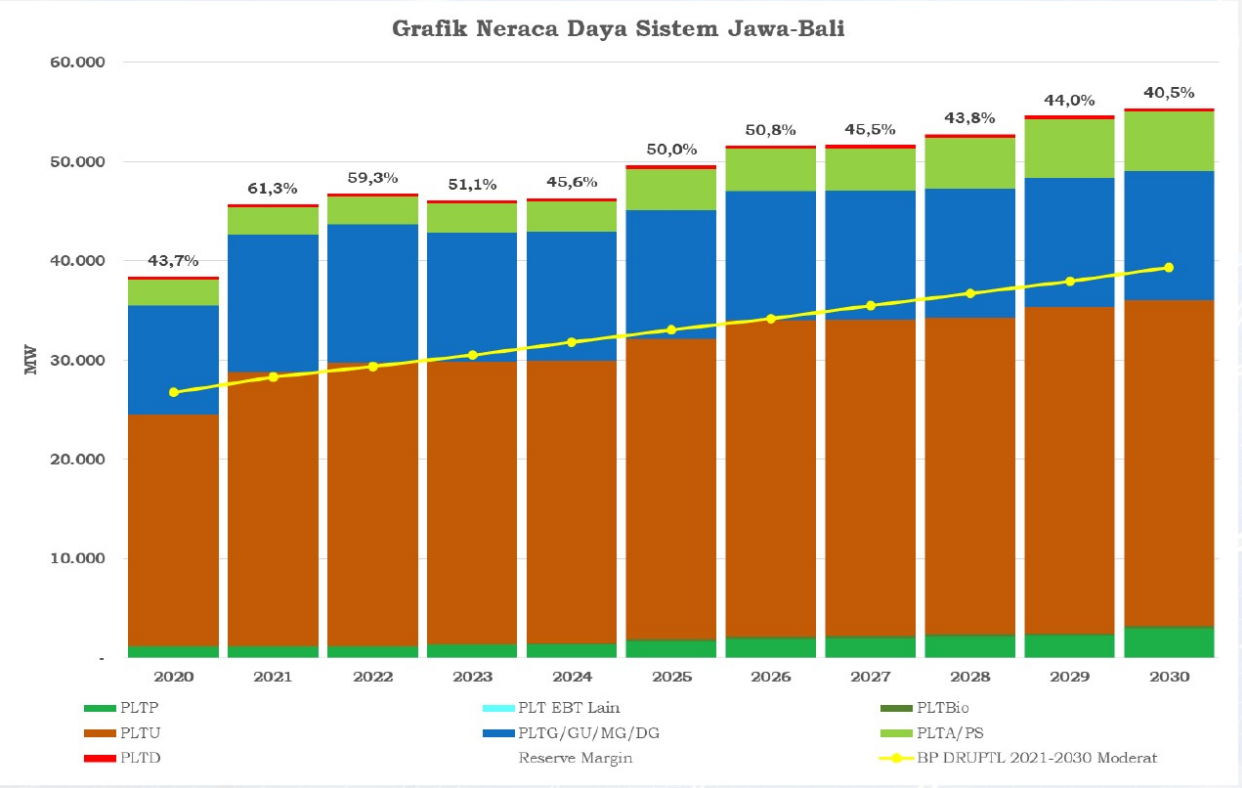
PLN's Market Reality



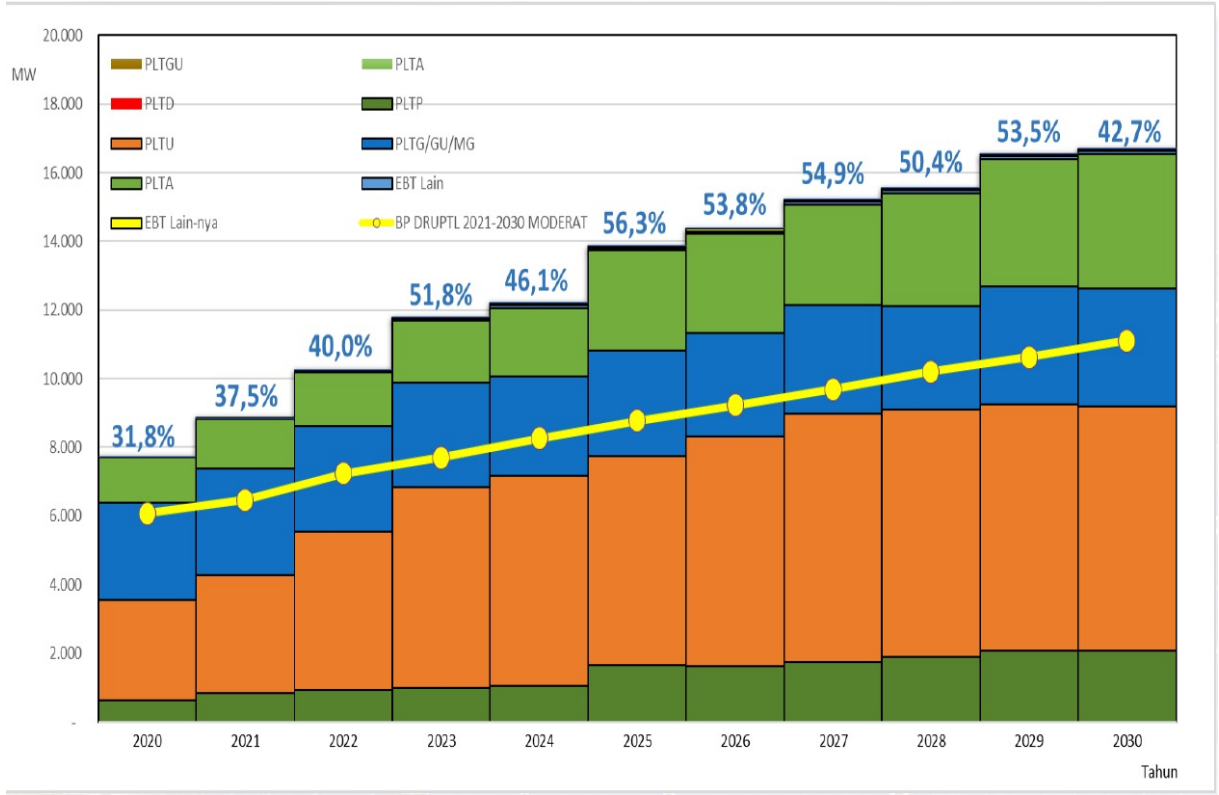
Demand has not grown as expected

PLN's Market Reality

Oversupply in Java-Bali grid

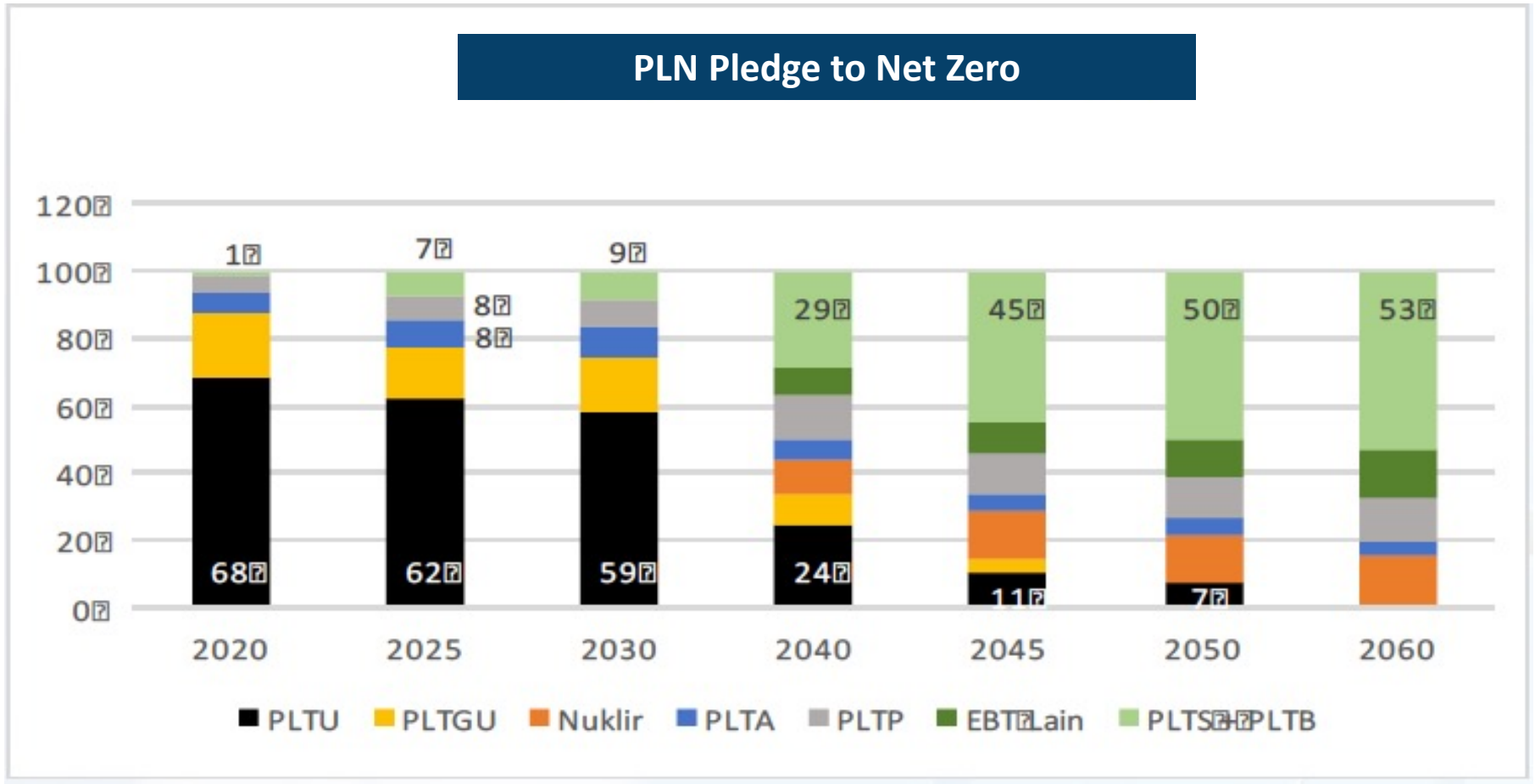


Oversupply in Sumatera grid



"Risk of having 40-60% of reserve margin in its system - approx. 7GW of unused power by 2029" - Minister of Energy & Mineral Resources

PLN's Market Reality



Nuclear only comes online in 2040

CONCLUSION

POTENTIAL

Baseload power

Promise of new Gen-IV SMR

Low GHG emissions

OPPORTUNITY

SMR technology – untested

PLN's market reality

Competition from renewables

UNADDRESSED RISKS & ISSUES

Safety, security & safeguard

Geographical & Geological Challenges

Reliability of Fuel Supply

Waste Disposal

Radiological risk

Third party liability insurance

Costs overruns, construction delays

Decommissioning & waste disposal cost

UNTIL THESE ISSUES ARE ADDRESSED, NET ZERO SCENARIO SHOULD BE REALISTIC AND CONSIDER OPTIONS THAT ARE ALREADY READILY AVAILABLE WITH LESS COST, LESS RISK, AND LESS FUTURE LIABILITIES