Can Indonesia Meet Net Zero Emission By 2060 Without Nuclear Power?

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IESR and MAREM Webinar
"On Eleven Year Ater Fukushima NPP Accident"

Jakarta, 11 March 2022

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The material and information that I convey in this presentation and discussion are my personal views and opinions as a professional and analist in the energy field. The personal opinion and views of a board member of the DEN [National Energy Council] do not necessarily reflect the opinions and views of the National Energy Council.

Jakarta, 11 March 2011

Herman Darnel Ibrahim

Board Member of DEN 2020-2025

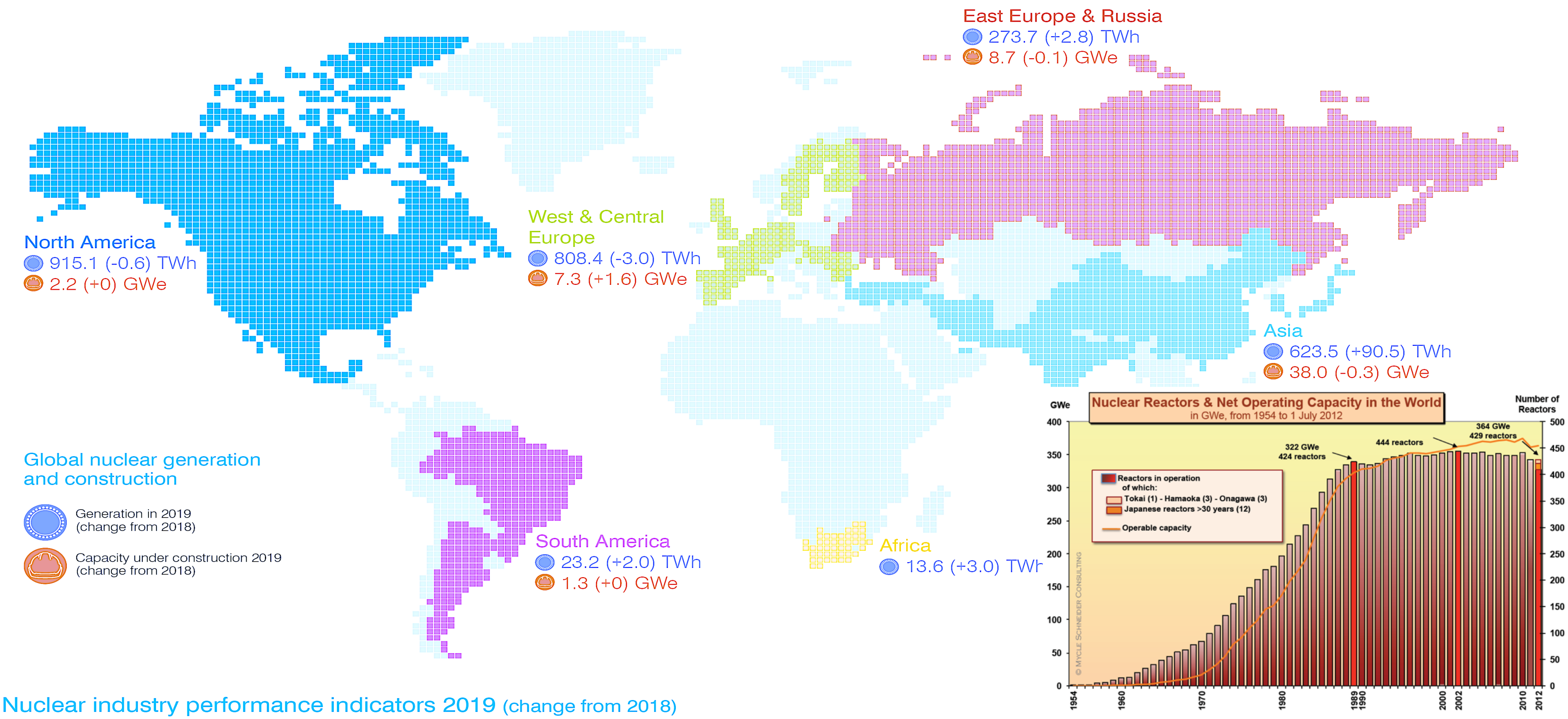
Energy Policy PP No. 79 Year 2014
Nuclear Is Last Option

Background And Consideration:

- Indonesia has sufficient Primary Energy Resources: Coal, Gas, and Renewables: Hydro, Geothermal, Biomass, Solar, Wind and Ocean.
- Those energy resources were considered more than enough for Indonesia energy suplly until year 2100
- The future LCOE of Nuclear Power was considered will be higher than of Coal, Gas, Hydro and Geothermal and in the future LCOE of Solar and Wind power will be cheaper than nuclear.
- Nuclear Power investment is much higher than of Coal SPP and Gas CCGT, and Indonesian condition requiring lower initial cost for its infrastructure development.
- With Nuclear power Indonesia will be dependent on other country for the technology, nuclear fuel and for the spent fuel treatment .
- Nuclear Security Risk, Indonesia is prone to earthquakes, risk of severe accidents to the economy, and vulnerability to attacks and terrorism.

Global Nuclear Power 2019*

Global Nuclear Generation and Construction



Nuclear industry performance indicators 2019 (change from 2018)

82.5% (+2.7%) Global mean capacity factor	2657 TWh (+95 TWh) Electricity generated in 2019	6 (-3) New grid-connected reactors	392 GWe (-5 GWe) End of year capacity	117 months (+14 months) Median construction period for new reactors grid connected in 2019

- Global Capacity 392 GW, decreased 4 GW [2011:429 GW]
- Average Construction for New Reactor is almost 10 Years

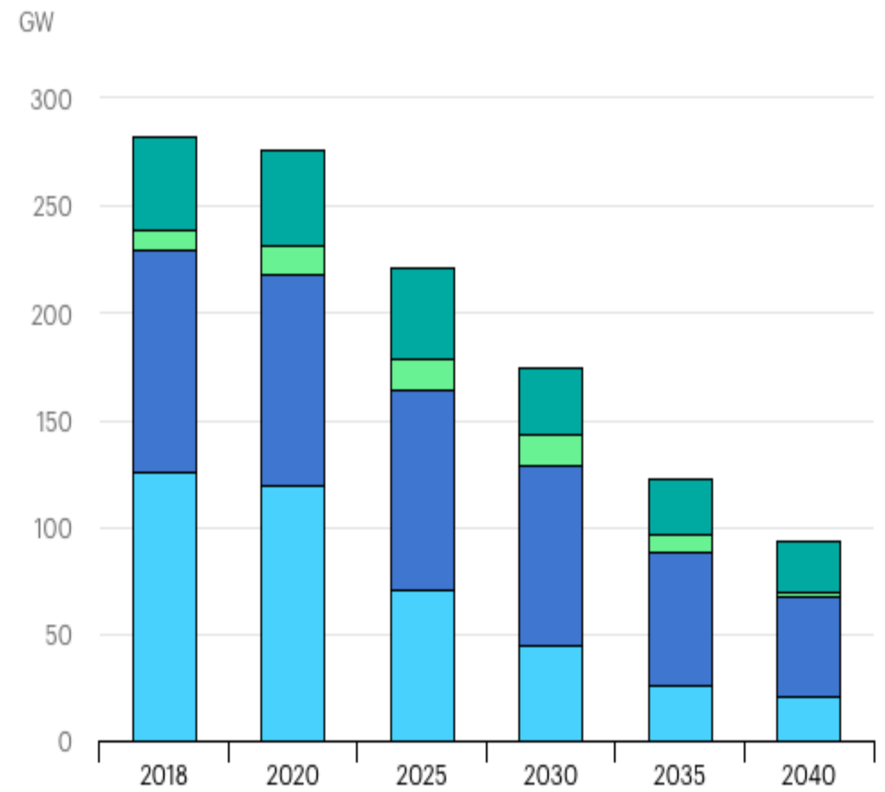
** Source : World Nuclear Association*

Global Nuclear Capacity Would Decline By Half [~200 GW] in 2040*

The Nuclear Fade Case

Given these challenges, there is a possibility that the nuclear fleet in advanced economies could face a steep decline. The IEA's Nuclear Fade Case explores what could happen over the coming decades in the absence of any additional investment in lifetime extensions or new projects.

Under this case, nuclear capacity operating in advanced economies would decline by two-thirds by 2040, from about 280 GW in 2018 down to just over 90 GW in 2040. The European Union would see the largest decline with the share of nuclear in the generation mix falling to just 4%. The share in the United states would drop from to 8%, and in Japan the share would fall to 2% - well below their 2030 target of 20-22%.



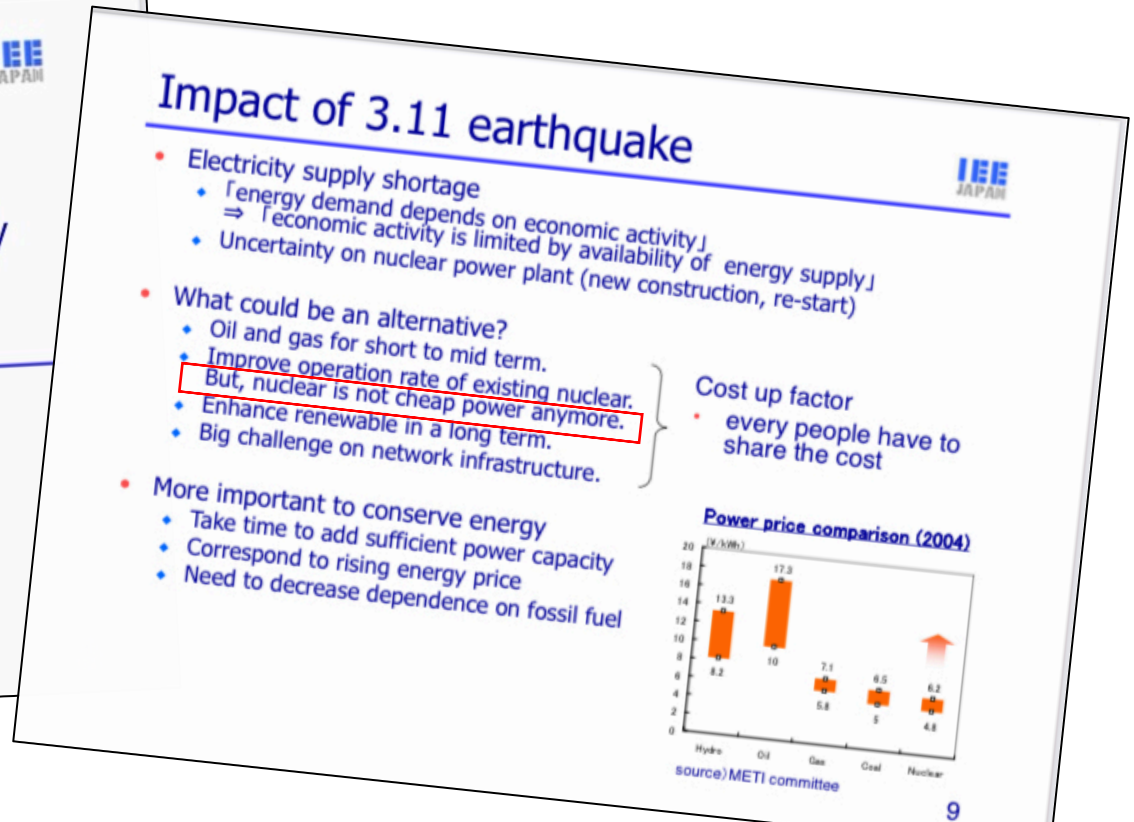
** Sumber: Power sistem in Transition, IEA Report 2020, www.iea.org*

European Union · United States · Japan · Other advanced economies

**Source: Nuclear Power in A Clean Energy System, iea.org, Fuel Report May 2019*

Post Fukushima With Ichiro Kutani San*:

At National Energy Council Office, July 2011



- Nuclear is considered not cheap energy anymore
- Indicating that Japan will not have more Nuclear Power Plant
- Japan will enhance renewable energy in a long term

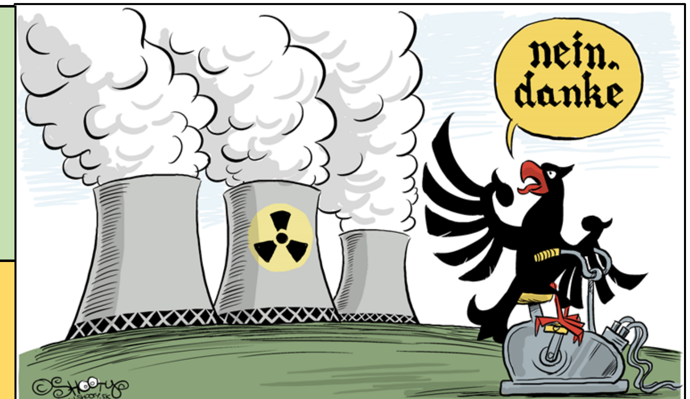
** Mr. Ichiro Kutani, The Institute of Energy Economics, Japan*

Nuclear Power Investment Is Very High:

USD 6,000 to 10,000 per Kilowatt

Region and Country	Overnight Cost USD per kilowatt	Investment Cost: Overnight+Financing [USD per kilowatt]				If 6 Years Delay [10 Years Construc-tion]
		On Time 4 Years	1 Year Delay	2 Years Delay	3 Years Delay	
Asia: China and South Korea	3500	4550	4800	5100	5400	6409
Erurope: EU and United Kingdom	5500	7150	7600	8000	8500	10105
North America: USA and Canada	5000	6500	6900	7300	7700	9122

Source: International Energy Agency [IEA] and Nuclear Energy Association [NEA] : "Nuclear Energy Road Map 2015" Interest Rate 6% per annum



Special Notes:

- **The investment to build 3,000 MW NPP [Nuclear PP] can build 30,000 to 40,000 Solar PV with more energy [two folds]**
- **Or 8000 to 10000 MW Coal SPP, or 18,000 to 24,000 MW Gas CCPP**
- **Most of NPP Construction experienced Cost Overrun [Average Delays 6 Years]**

LCOE of Nuclear Power Is Expensive:

USD 12-16 Cents per kWh

An October 2020 report from Lazard compared the LCOE for various generation technologies on the basis of its estimates, related to input from "a wide variety of industry participants". **For nuclear power [2200 MWe plant], capital cost including financing [at a high discount rate] ranged from $7675 to $12,500 per kilowatt, and the LCOE accordingly varied from $129 to $198/MWh**. For a 600 MWe coal plant the capital cost ranged from $3000 to $8400/kW, giving an LCOE of $60 to $143/MWh. Gas combined cycle [550 MWe] capital cost was $700 to $1300/kW and LCOE $65 to $159/MWh. The purpose of the study was to compare these figures with "alternative energy technologies", particularly wind and solar PV, but without taking account of system costs. The nuclear costs estimated by Lazard were well above those in the IEA-NEA study based on existing projects, with well-referenced data.

Source: Economics of Nuclear, world.nuclear.org Up dated September 2021

"Nuclear power is now the most expensive form of generation, except for gas peaking plants"

September 24, 2020 Emiliano Bellini

The latest edition of the *World Nuclear Industry Status Report* indicates the stagnation of the sector continues. Just 2.4 GW of net new nuclear generation capacity came online last year, compared to 98 GW of solar. The world's operational nuclear power capacity had declined by 2.1%, to 362 GW, at the end of June.

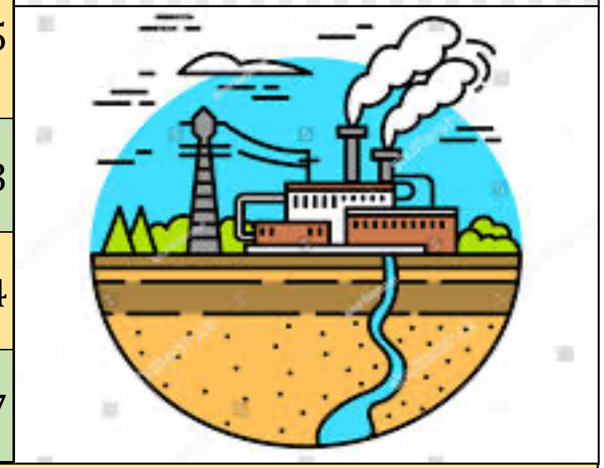
The LCOE from nuclear power rose from around $117/MWh in 2015 to $155 at the end of last year [2019], according to the latest edition of the *World Nuclear Industry Status Report*, published annually by French nuclear consultant Mycle Schneider.

By contrast, the LCOE from solar power decreased from $65/MWh to approximately $49 and that of wind from $55 to $41.

Source: pv-magazine.com

Estimated Indonesia Electricity Consumption 2020-2070 [NZE 2060 Scenario]

Desription	Unit	2020	2030	2040	2050	2060	2070
Population	Million	270	294	318	343	368	392
Electricity Consumption [High Scenario]	TWh	300	616	1282	2113	2930	3305
Avg Annual Growth [High]	%	NA	7,5	7,6	5,1	3,3	1,2
Electricity Consumption [Low Scenario]	TWh	300	539	1026	1733	2441	2765
Avg Annual Growth [Low]	%	NA	6,0	6,6	5,4	3,5	1,3
Consumption Per Capita [High]	kWh	1111	2096	4029	6161	7968	8424
Consumption Per Capita [Low]	kWh	1111	1834	3223	5055	6640	7047

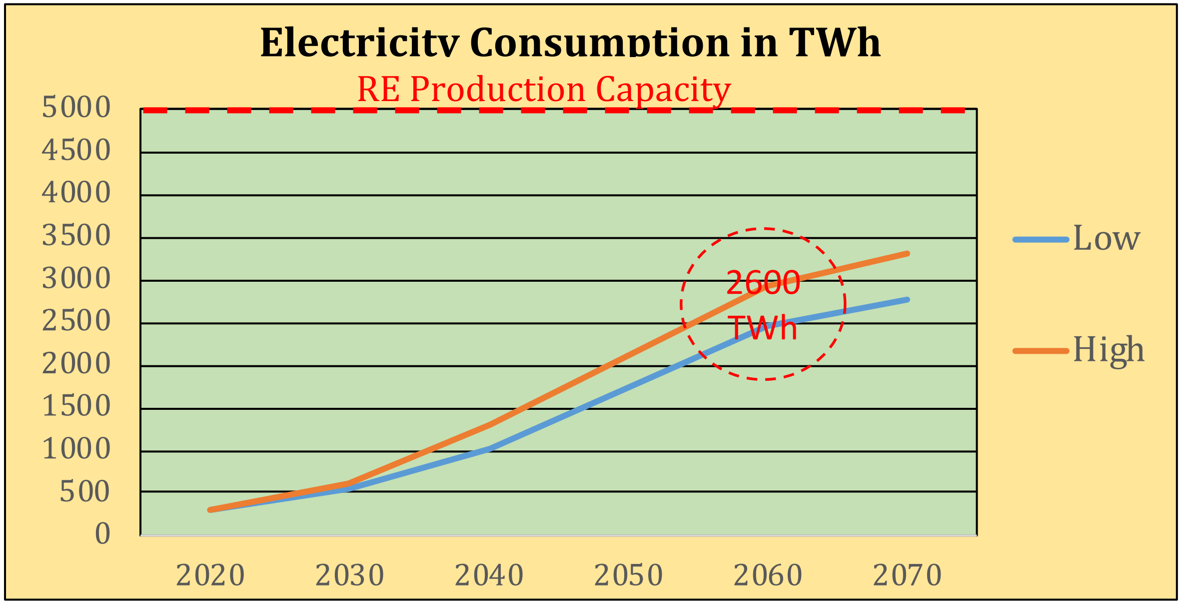


Consumption of Electricy in 2060 will be around 2600 TWh with Per Capita Consumption of about 7000 kWh [Assuming most of use of fossil final energy in transportation and industry will be switched to electricity]

Indonesia Renewable Energy Reserve:

Estimate of Exploitable and Utilisable Capacity

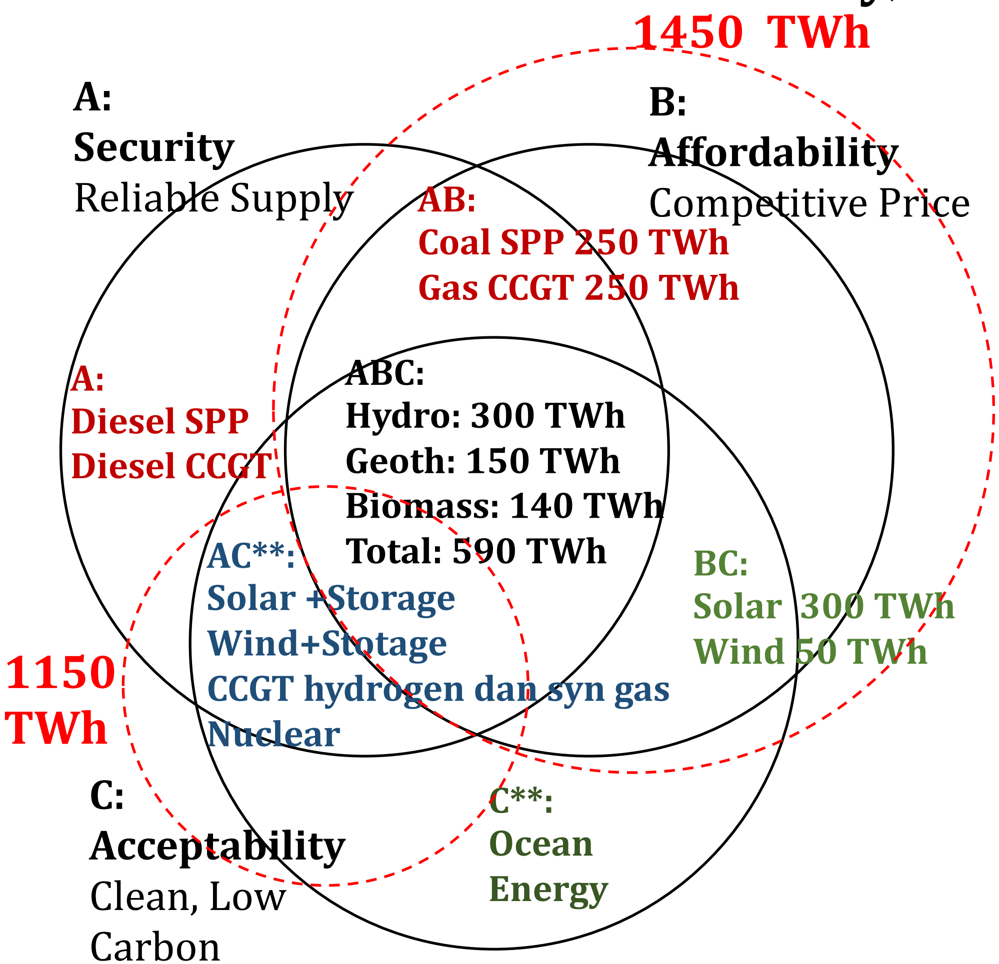
Primary Energy Source	Reserve or Potential [GWe]	Practical Exploitable [GWe]	Utilisable Capacity 2060 [GWe]	Energy Capacity 2060 [TWh]
Hydro Power	94	85	75	300
Geothermal	29	25	20	150
Solar	**3000+**	**3.000**	**3.000**	**4.500**
Wind	**61**	**40**	**40**	**100**
Biomass	33	30	20	140
Ocean	18	6	4	10
Total	**3.217**	**2.220**	**2.155**	**5.200**



- **The Agregate National Renewbale Energy Production Capacity over 5000 TWh is sufficient to supply the projected electricity consumption of ~ 2600 TWh in 2060.**
- **The Challenge is the Technology for Variable Renewale Energy [Solar and Wind] Integration to the Power System, and the invention of Cheaper Battery [Energy] Storage.**

Electricity Supply By 2060:

Balance of Security, Affordability dan Acceptability



*** not economical*

Gross Consumption 2060 : ~2600 TWh
Per Capita Consumption: ~ 7000 kWh

Electricity Supply:

- Coal SPP 35 GW: 250 TWh [125 million T ~ 60 MTOE] CO2 Emission captured by CCUS [AB Section]
- Gas CCGT 250 TWh [2 TCF gas~50 MTOE]
- Hydro dan Geothermal, Biomass: 600 TWh [ABC Section]
- Wind and Solar Without Energy Storage: 350 TWh [BC Section]

Sub Total of Economic Supply : 1450 TWh

Still Need To Balance 2600-1450: 1150 TWh

The balance of 1150 TWh can be supplied by AC Section :

1. *Fully by Solar and Wind Power with Storage*
2. *Solar and Wind with Storage and H2, Biomass Fueled CCGT*
3. *Combination of option 1 or 2 with Nuclear Power*

Energy Mix Scenario For NZE 2060:

Option Without Nuclear Power

Energy Efficiency and Conservation

Maximizing Hydro Power: 300 TWh
75 GW, Apply REBID Policy

Maximazing Geothermal Power: 150 TWh
20 GW, Apply REBID Policy

Maximizing Biomass: 140 TWh
20 GW

Wind: 50 TWh
20 GW, With Ancil. Serv. [Storage]

Solar: 300 TWh
200 GW With Ancil. Serv. [Storage]

Coal USC: 250 TWh
35 GW, With CCUS

Gas CCGT: 250 Twh
35 GW, CO2 Emission to be neutralized by Forest

Ocean: 10 TWh
4 GW

Wind: 50 TWh
20 GW With Massive Storage

Solar: 1100 TWh
750 GW With Massive Storage

1450 TWh of 2600 TWh Consumption

1150 TWh Without Nuclear

Smart Grid

To Close

- Indonesia can meet its NZE by 2060 without nuclear power, by maximizing conventional renewable electricity; hydro power, geothermal and biomass and develop massive solar energy with a capacity of hundreds of Gigawatts
- The conditions needed to be able to meet Net Zero Emissions by 2060 without nuclear power plants are:
  - The successful invention of Technology for up to 75% penetration of VRE to the Power Grid.
  - The successful development of cheaper energy storage that enable the development of VRE with several days of storage capacity.
  - LCOE of solar and wind energy with several days of storage is cheaper than the LCOE of Nuclear energy.
- Alternatively it can also be fulfilled without nuclear if Consumers share the cost [of storage] by accepting the cost consequences.

Biography of Herman Darnel Ibrahim

Herman Darnel Ibrahim, who is fondly called HDI, was born in Payakumbuh in 1954. HDI is a Member of the DEN for the period 2020-2025 and the period 2009-2014. Several important positions previously were Member of DPD RI 2014-2019 [PAW], Directors of PT. PLN [2003-2008] and the Directors of PT. Indonesia Power [1998-2003]. Other activities are as an Analyst and Advisor in the field of electricity and energy, and also as a Lecturer for the Masters Program at the Faculty of Engineering, University of Indonesia.

After graduating from high school in Payakumbuh at the end of 1972, HDI continued his education to ITB Bandung, and he got his First Degree [Ir] in Electrical Engineering in 1978. After graduating from ITB he immediately worked at PLN and in 1986 he received a scholarship for thePost Graduate program at the University of Manchester, England and graduated as a Master of Science in the field of Power Systems in 1988. In 1995 while remaining the top executive of PLN, he attended the Doctoral program at ITB and graduated as a Doctor in 2004. From 2006 to 2011 he was a Lecturer for the Master Program at School of Electrical and Informatics Engineering, STEI ITB. In 2009 he was appointed as Adjunct Professor at UNITEN [Universiti Tenaga Nasional] Malaysia.

For almost 30 years from 1978 to 2008, HDI worked at PT PLN Persero. With the last position as Director of Transmission and Distribution of PLN in 2003-2008. Several important positions he has held at PLN are: Director of Commerce of PT Indonesia Power [a subsidiary of PLN] from 1998 to 2000, and Director of Human Resources and Organization of PT Indonesia Power, from 2000 to 2003, and President Director of PT Cogindo DayaBersama [a subsidiary company PT Indonesia Power] from 1998 to 1999.

HDI is active in various non-profit professional organizations in the field of Energy including being Chair of API, Indonesian Geothermal Association [2001-2004], and currently he still sits as Chairman of the MASKEEI Expert Council, Indonesian Energy Conservation and Efficiency Society, METI Board of Trustees, Renewable Energy Society Indonesia; API Advisory Board; MKI Expert Council, Indonesian Electricity Society; PII BKE expert board, ASELI Advisory Board, Indonesian Marine Energy Association; AESI Expert Council, Indonesian Solar Energy Association.

HDI is also active in international organizations, namely as Chairman of the Indonesian National Committee of CIGRE [International Council of Large Electric systems] since 2006, Chairman of CIGRE Regional Asia and Oceania 2008-2010 and Vice President of IGA, International Geothermal Association [2013-2016].

Terima Kasih
Thank You

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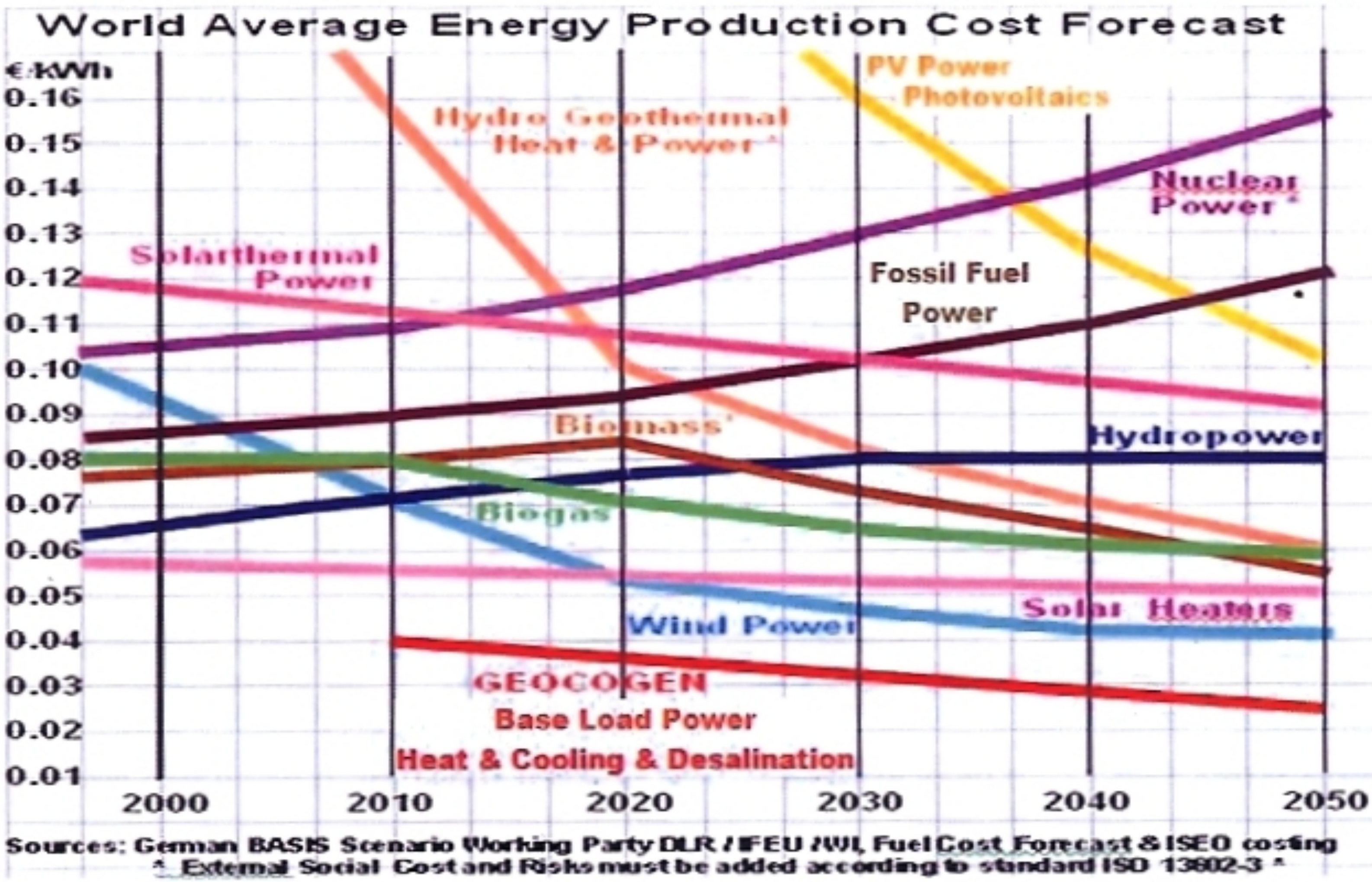
Attachment 1: Projected Trends of Electricity Production Cost*



** Prof Gustav Grob, President of ISEO*

Attachment 2: RE Electricity Characteristic*

Primary RE Sources	RE Technology	Technology Development Status	Technology and Cons. Cost [USD per kW]	Production Cost [USD cents per kWh]	Typical Availability	Capacity Factor [%]
Renewable						
Wind	On Shore	Developed	1000-3500	4-16	Intermittent	15-50
	Off Shore	Developing	2000-6000	9-27	Intermittent	20-50
Solar	Photo Voltaic	Developed	900-6000	5-26	Intermittent	10-30
	Thermal	Developing	3500-9000	12-50	Intermittent	11-50
Biomass	Solid Waste	Developed	800-6000	3-20	Base Load	30-90
	Biogas	Developed	800-6000	3-20	Base Load	30-90
Hydro	Large	Developed	800-2500	3-10	Semi Base Load	30-70
	Small	Developed	600-5500	2-23	Base Load	50-80
Geothermal	Hydrothermal	Developed	2000-7000	4-13	Base Load	70-95
	EGS	Research	NI	NI	Base Load	NI
Marine	Wave, Tidal	Slow Developing	5000-6500	21-28	Intermittent	20-30
	OTEC	Slow Developing	NI	NI	Intermittent	NI
Fossil						
Coal	Steam PP	1700-2000	1700-2000	5-9	Base Load	80-90
	Steam PP-SC	2200-2600	2200-2600	6-10	Base Load	80-90
	Steam PP-CCS	3600-4000	3600-4000	11-14	Base Load	80-90
Gas	CCGT	1000-1200	1000-1200	6-7	Base Load	60-90
Nuclear	Nuclear PP	6600-9000	6600-9000	11-12 *	Base Load	80-90

Notes: OTEC=Ocean Thermal Energy Conversion, PP=Power Plant, SC=Super Critical, CCS=Carbon Capture and Storage, CCGT=Combined Cycle Gas Turbine, NI=No Information

**Data Source: Renewable Energy Statistics, IRENA*