Utilizing CCS/CCUS technology to achieve "Net Zero Emission" (NZE)

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- Introduction

OUR GLOBAL PROBLEM

Promoting a balance between earth resource-based prosperity and environmental sustainability

e.g:
Energy & resources required
Climate changes
CO_2 Emission

Prosperity

What is required?
Ethics
Standard
Human Behaviour

ENVIRONMENT

EQUILIBRIUM

The role of CCS/CCUS

AWARENESS
TECHNOLOGY DEVELOPMENT
NRE & CCS/CCUS

Low carbon society
Energy Transition

Sustainability

Indonesia toward Net Zero Emission (Source of data: IEA, 2023)

- Indonesia Development (2023):
  - GDP: 10 X year of indepence (1945)
  - Poverty: 60%(1970)➔10%
  - 4th Populous country.
  - 7th largest economy
  - 12th largest energy consumer.
  - Largest coal exporter.
  - Net oil exporter 2003.
  - Oil & Gas Share to GDP: 10%(2000) ➔ 2.5%(2021)
  - Revenue (Oil & Gas): decrease fourfold
  - Export (coal & natural gas): 20% of net export.
  - Total energy supply: increase 60% (2000-2021).
  - Energy sector emission: 600 (Mt CO_2) (2021)(2X(2000)
  - 9th largest emitter of CO2:

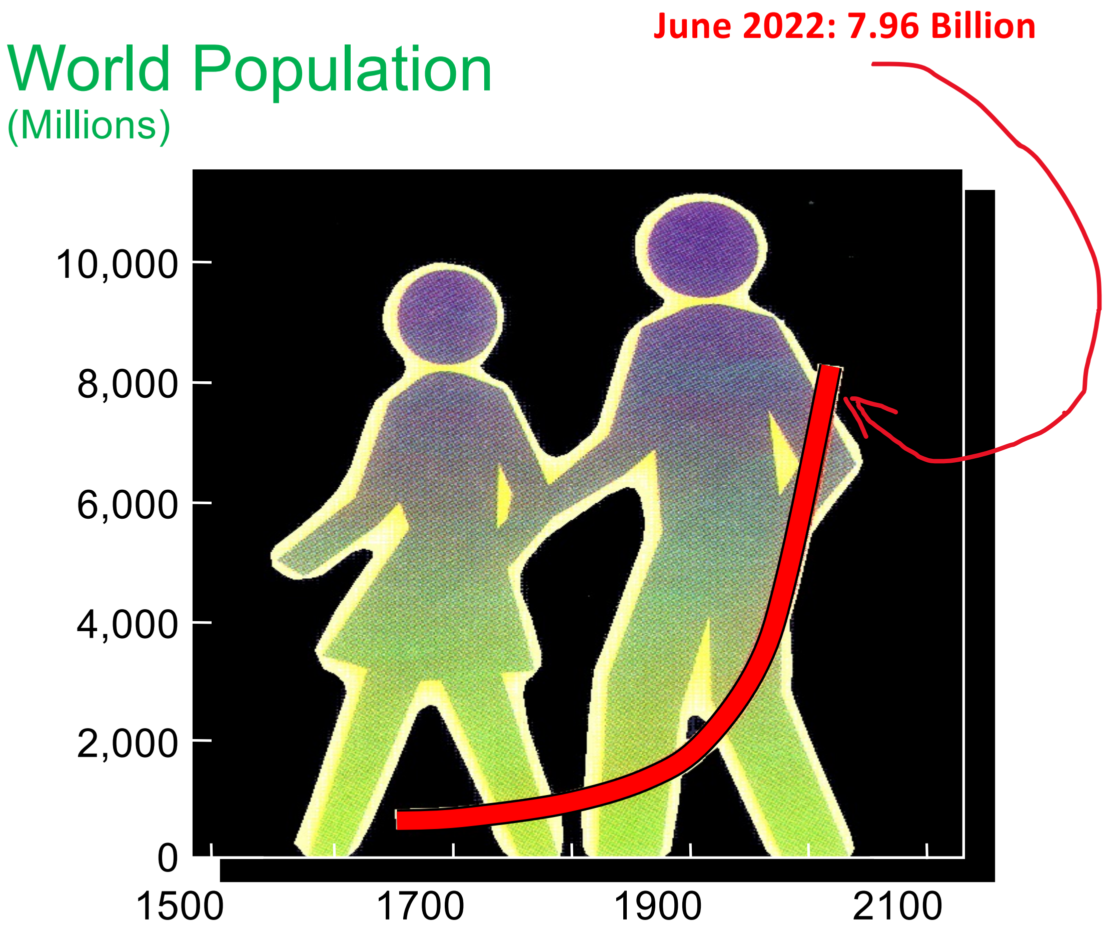
- Indonesia Development (2023) ➔ CO_2 Emission:
  - Indonesia **still highly dependent** on fossil fuels.
  - Energy sector emission: 600 (Mt CO_2) (2021)(2X(2000))
  - **9th largest emitter of CO2**
  - Per capita energy CO2: 2 tonnes. (half of global average)

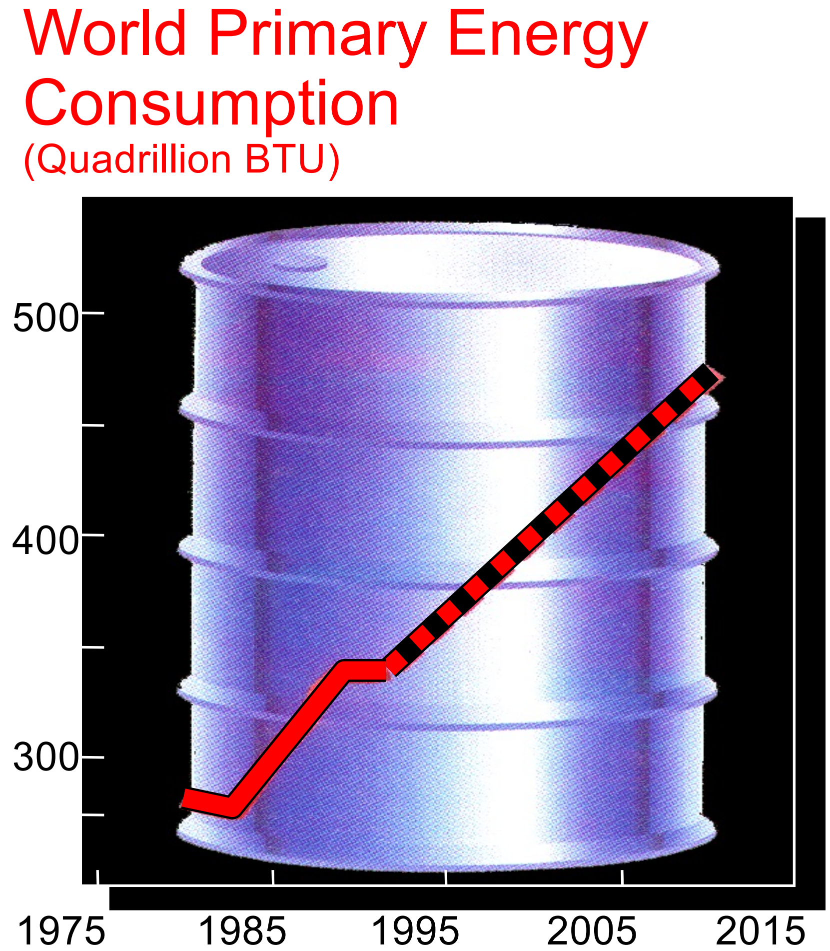
- Challenge to Indonesia Net Zero Emission 2060:
  - Indonesia **still highly dependent** on fossil fuels.
  - Energy sector emission: 600 (Mt CO_2) (2021)(2X(2000)
  - 9th largest emitter of CO2:
  - GDP/capita 30% < 30% avg world..
  - Economic regional imbalance: Java & Bali contribute 75% GDP.
  - Economically: Highly resources dependent.

- Transformation toward advanced economy 2045:
  - Economic Diversification.
  - Economic driven by knowledge, technology and innovation.
  - Clean energy development:
    - **Energy transition (included Geothermal)**
    - Fossil Fuel low carbon Technology (Clean coal technology, **CCS/CCUS**, co-firing biomass, diversification down stream coal industry)

(PPSDMA-ESDM, 2023)

Energy demand increase by increasing world population

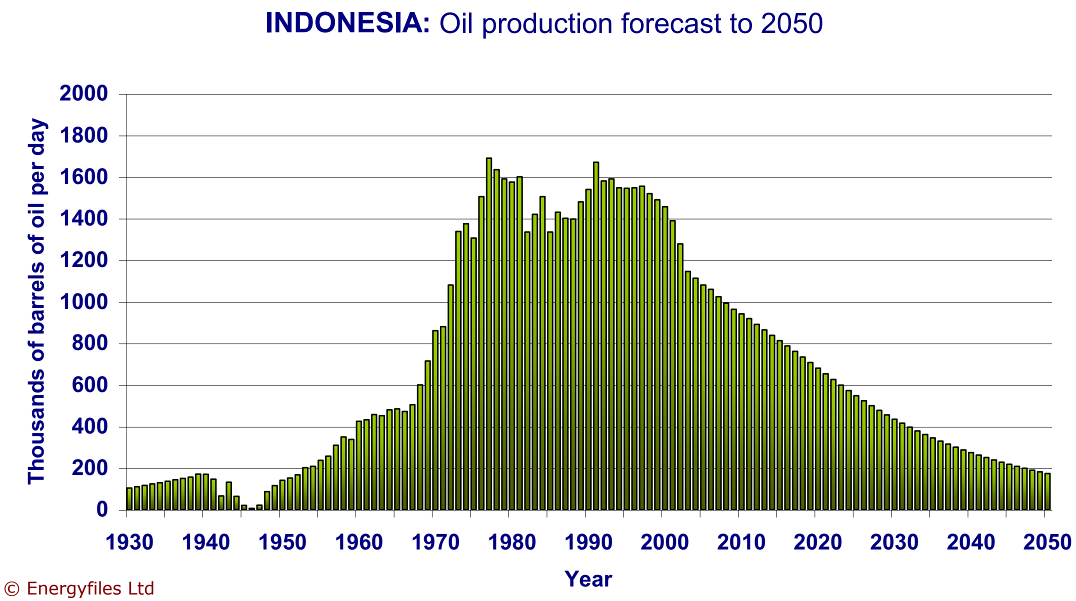


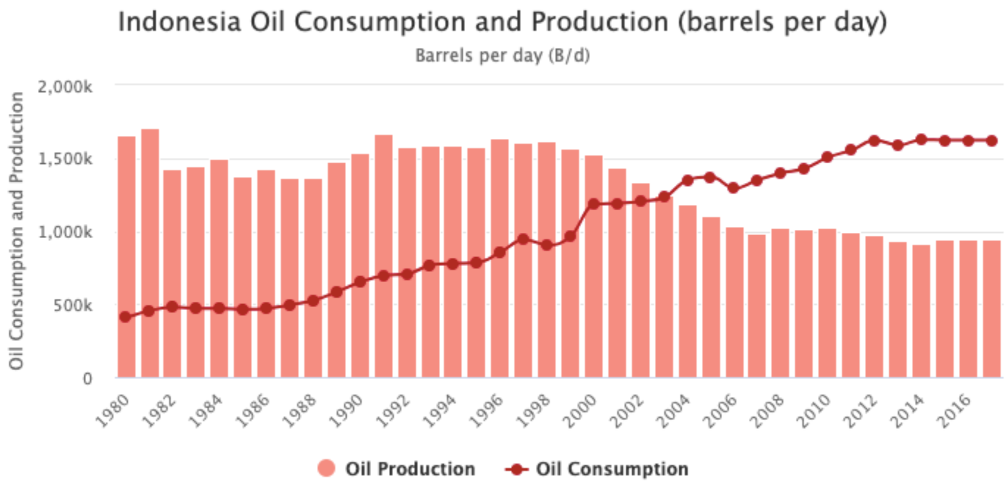


AAPG Explorer, 8/95

Resource Scarcity

History of Indonesia from oil exporting country to importing country



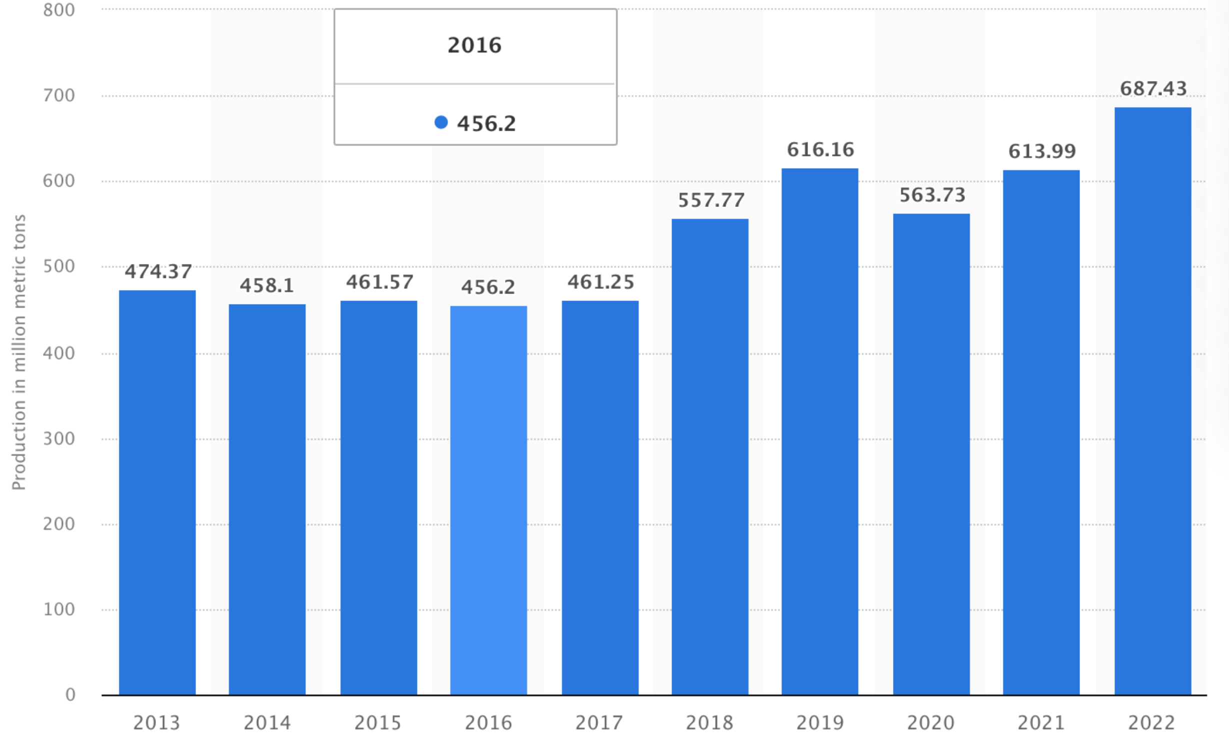


(Wolrdometer, 2021)

There is some space in the reservoir that could be utilized

Resource Scarcity

Coal production in Indonesia from 2013 to 2022 (in million metric tons), Statista (2023)



ENERGY INDICATOR OF SOME COUNTRIES

Indicator	Unit	Indonesia	Malaysia	Vietnam	Japan	Asia (non OECD)	World
Population	mio	257.6	30.3	91.7	127.0	2,438	7,334
GDP	Miliar 2010 USD	987.5	330	154.5	5,986.1	5,948	75,489
TPES	Mtoe	225.4	96.5	73.8	429.8	1,769	13,790
Elelectric consumption	TWh	211.9	141.2	140.7	998.7	2,397	22,386
Emission CO_2	Mt of CO_2	441.9	220.4	158.3	1141.6	3,887	32,294
TPES/capita	toe/kapita	0.87	2.83	0.73	3.38	0.73	1.86
TPES/GDP	toe/000 2010 USD	0.23	0.26	0.46	0.10	0.3	0.18
Electric consumption/capita	KWh/kapita	910	4.656	1,534.37	7,865	983	3,052
CO_2/TPES	tCO_2/toe	1.96	2.36	2.28	2.66	2.2	2.37
CO_2/capita	tCO_2/kapita	1.72	7.27	1.83	8.99	1.59	4.4

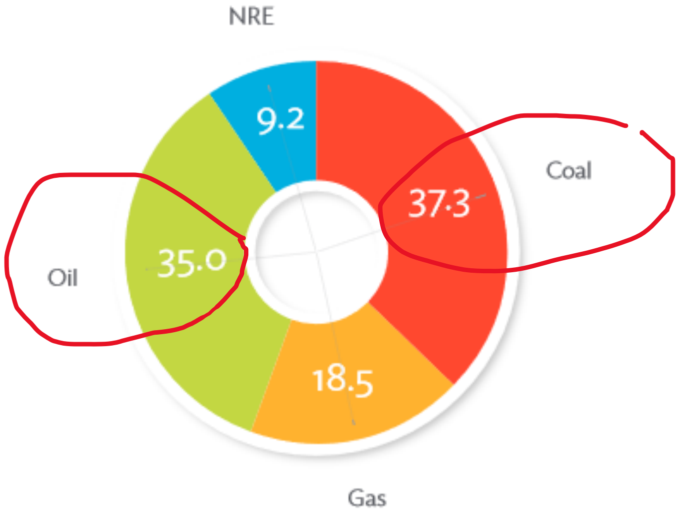
Proven reserve indicator	Unit	Indonesia*	World**
Oil	Miliar barel	3.31	1,706.7
Coal	Miliar ton	16.97	1,139.3
Gas	Trilllion cubic feet	101.22	6,588.8

Source: * ESDM (data 2016); ** BP Statistical Review of World Energy 2017 (data 2016)

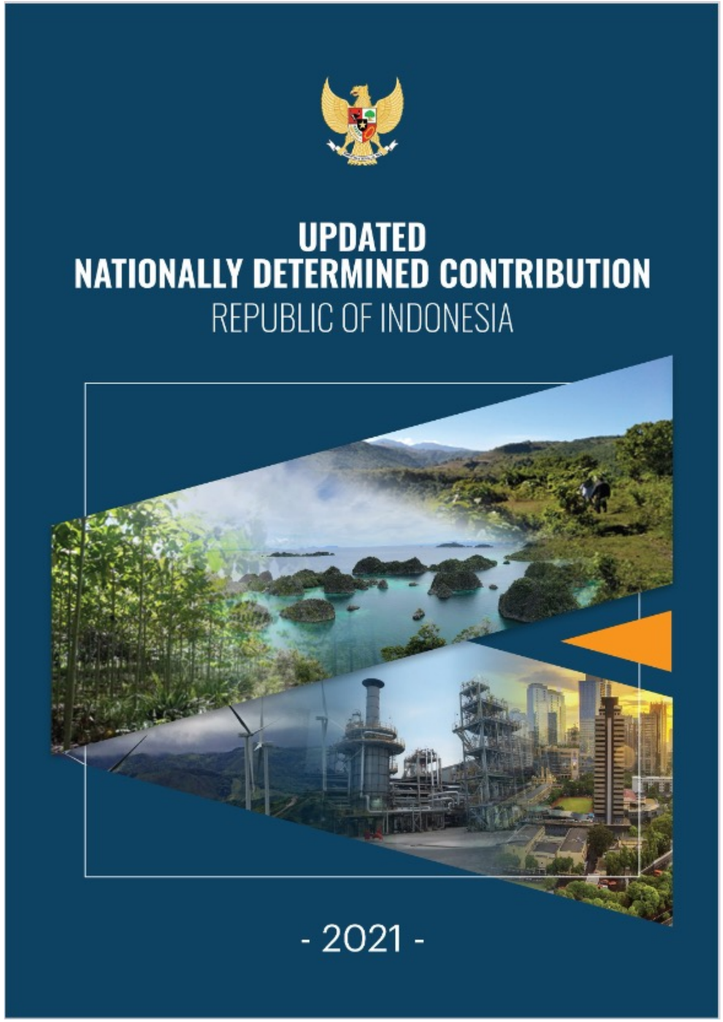
- Efforts to reduce CO_2

Indonesia Plan to reduce CO_2 emission will be related to CCS/CCUS

- Indonesia is planning for progression towards net zero emission in 2060 based on the NDC document submitted in 2021
- Indonesia's power generation is highly reliant on coal & other fossil fuels, where almost 90% of energy supply is taken from fossil fuel.



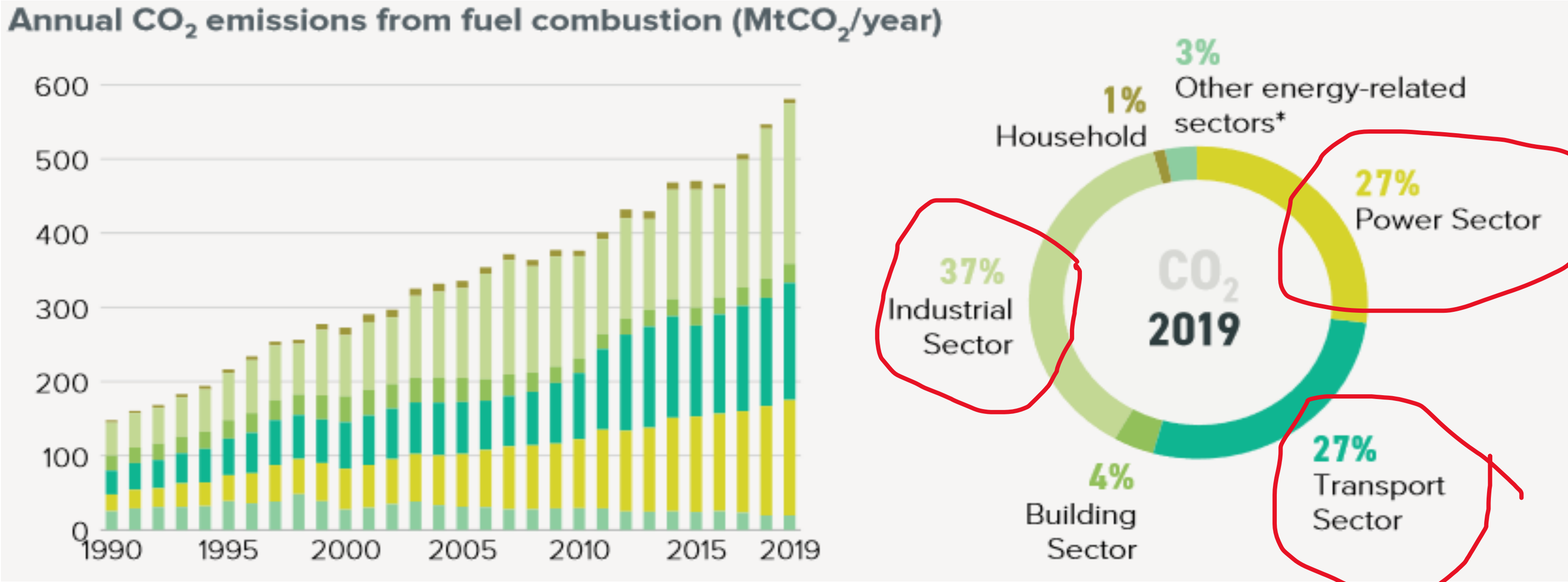
Source: Ministry of Energy and Mineral Energy Handbook (2019)



Center for CO_2 & Flared Gas Utilization

INDONESIA CENTER OF EXCELLENCE CARBON CAPTURE STORAGE

CCS/CCUS as a potential technology to reduce CO_2 emission in big scale



- CCUS in Indonesia has a potential to delve into potential CO_2 sources in Industrial & Power Generation sector.
- The Gov't of Indonesia is currently preparing regulations for carbon credit and its related instruments.

Source: Indonesia Climate Transparency Report (2020)

Center for CO_2 & Flared Gas Utilization

INDONESIA CENTER OF EXCELLENCE CARBON CAPTURE STORAGE

Environmental Sustainability

CO2 reduction? Use the NRE Power Generator or Environmentally Clean Energy (Fossil Energy with No Emission such as application of CCS/CCUS in Industrial activity)

Don't misunderstand

"The use of electric vehicles will be meaningful if the energy transition is successful"

Environmental Sustainability

Interactive Task: Lifecycle Carbon Assessment for Automobiles

For vehicles in US midwest

Green credentials

Average lifecycle for car in US midwest

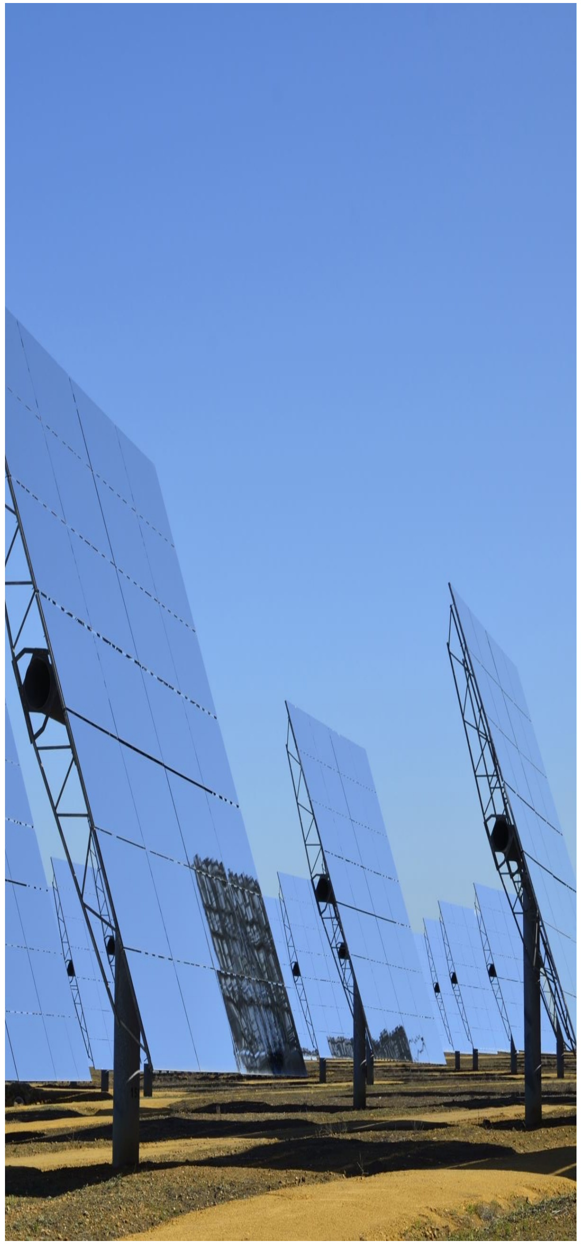
	Tesla Model S P100D (battery-electric vehicle)	**BMW 7 Series 750i xDrive** (internal combustion engine)	**Mitsubishi Mirage** (internal combustion engine)
Production emissions (kg CO_2 equivalent)	12,204	8,190	4,752
Use emissions - 270,000km (kg CO_2 eq)	48,600	95,310	46,980
End of life emissions (excluding battery, kg CO_2 eq)	311	351	159
Lifecycle emissions total - 270,000km (kg CO_2 eq)	61,115	103,851	51,891
Lifecycle emissions per km - intensity (g CO_2 eq/km)	226	385	192

All data are based on vehicles driven in the US midwest
Source: Trancik Lab, MIT
© FT

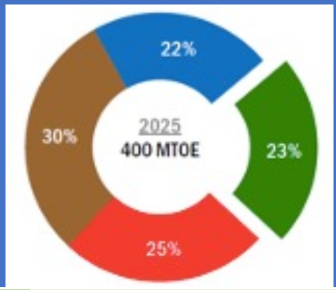
Indonesia applies five main principles Indonesia to reduce the carbon footprint and achieve net zero emissions (PPSDMA-ESDM, 2023):

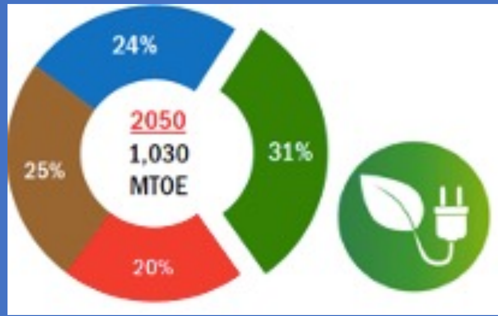
- **Increasing the use of new and renewable energy (EBT); ✓(Bioenergy, Hydroenergy, Solar, Wind, Geothermal)**
- Reduction of fossil energy;
- Use of electric vehicles in the transportation sector;
- Increasing electricity use in households and industry; and
- **The use of Carbon Capture and Storage (CCS) & (CCUS) ✓**

Note: ✓ the geophysical technology has an important role.



Energy Mix Target 2025-2050



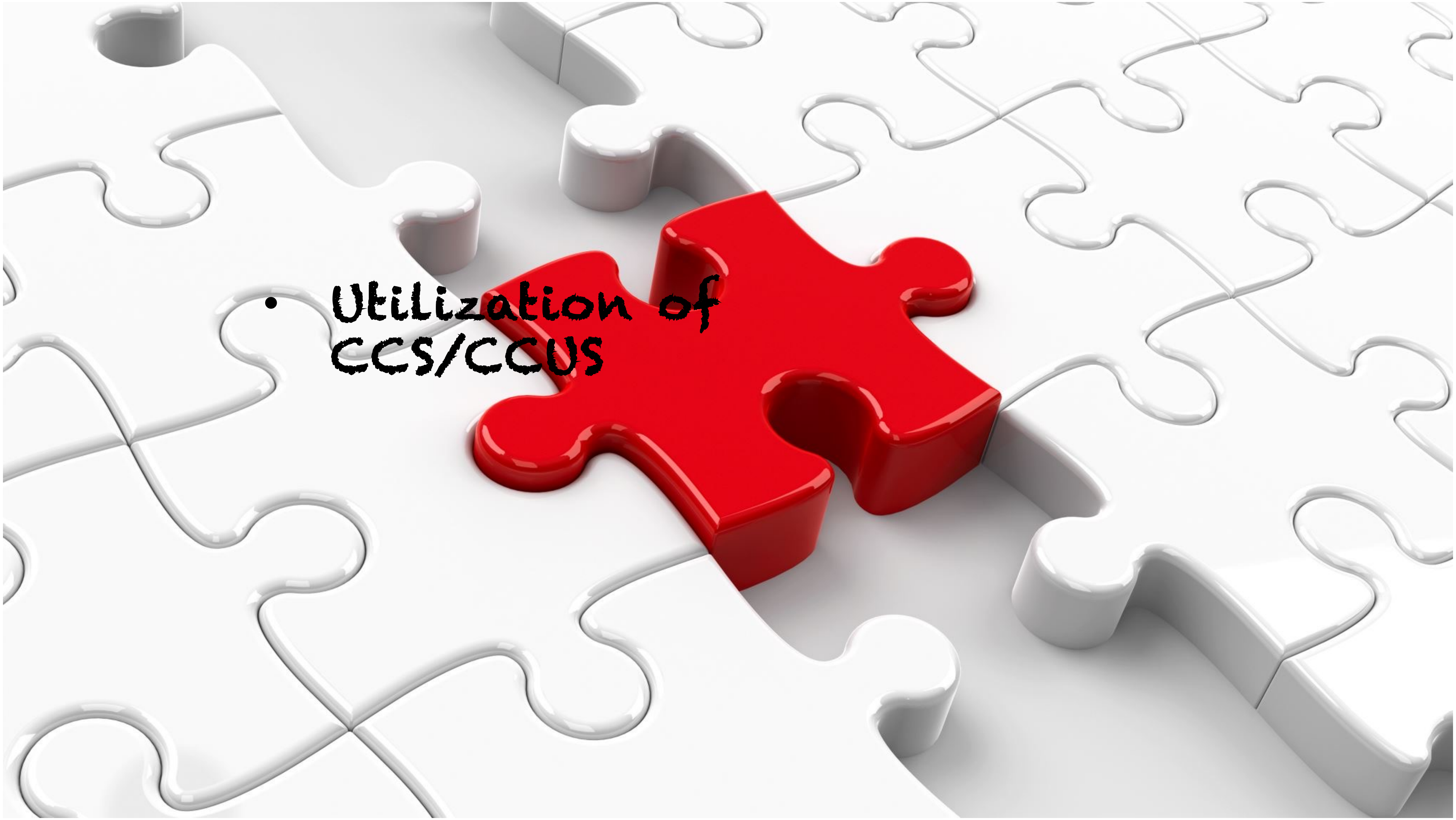


NRE
Coal
Oil
Gas

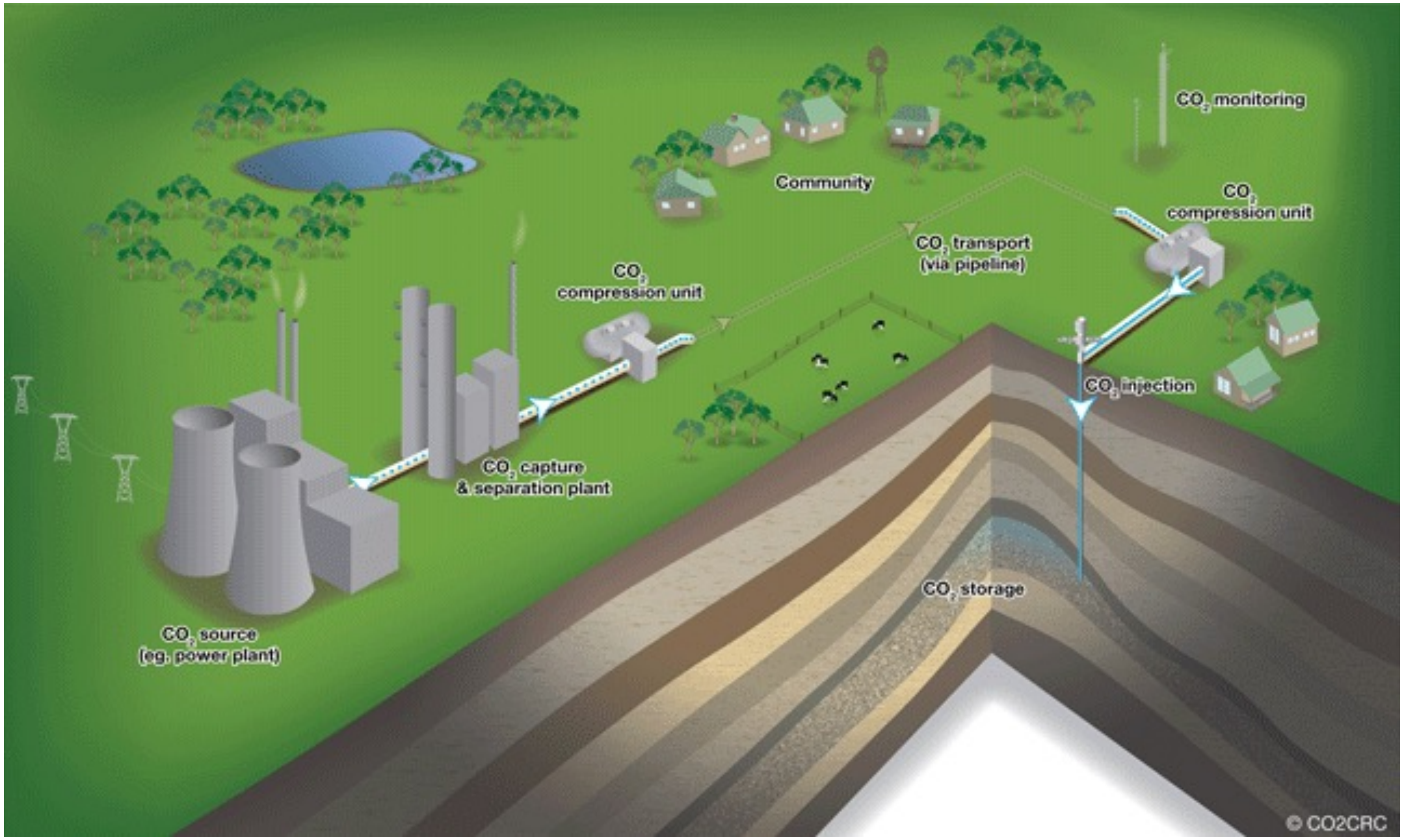
2025 New and Reneable Energy 45 GW	1. Geothermal 7.2 GW
	2. Hydro 17.9 GW
	3. Microhydro 3 GW
	4. Bioenergy 5.5 GW
	5. Sun 6.5 GW
	6. Wind 1.8 GW
	7. Other 3.1 GW

Type of Power Generator (GW)	2025	2050
Geothermal	7.239	17.546
Hydro & Microhydro	20.960	45.379
Bioenergy	5.532	26.123
Sun	6.379	45.000
Wind	1.807	28.607
Others	3.128	6.383

Source: KESDM



- Utilization of CCS/CCUS

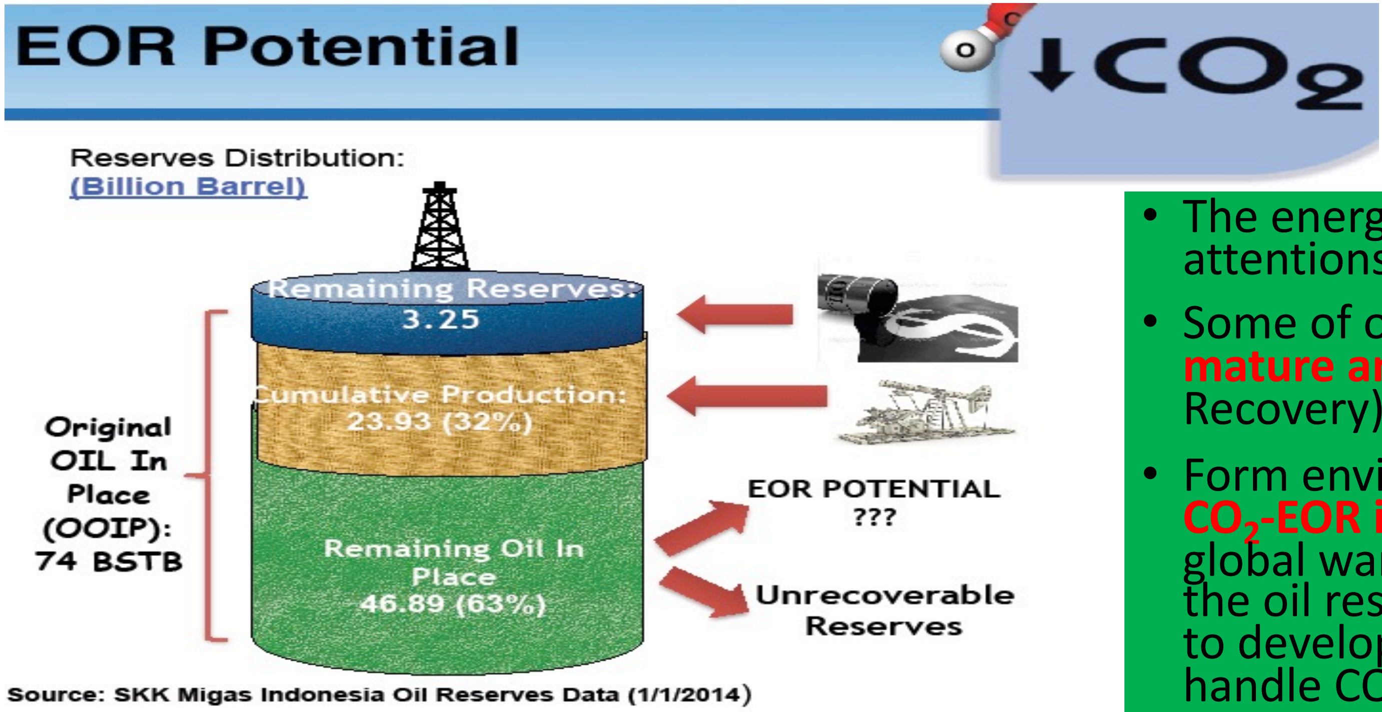


Source: CO2CRC

- CCS can be applied to reduce CO_2 emissions from various sources, including:
  - Electricity power generation
  - Cement industry
  - Iron & steel industry
  - Oil refinery
  - Petrochemicals, fertilizers
- The separated CO_2 is then transported using pipes or ships
- Then, CO_2 is injected into wells that have good and safe characteristics

- CO2 can be utilized (utilization), for example for enhanced oil recovery (EOR)CCS

Why CCUS important in Indonesia?



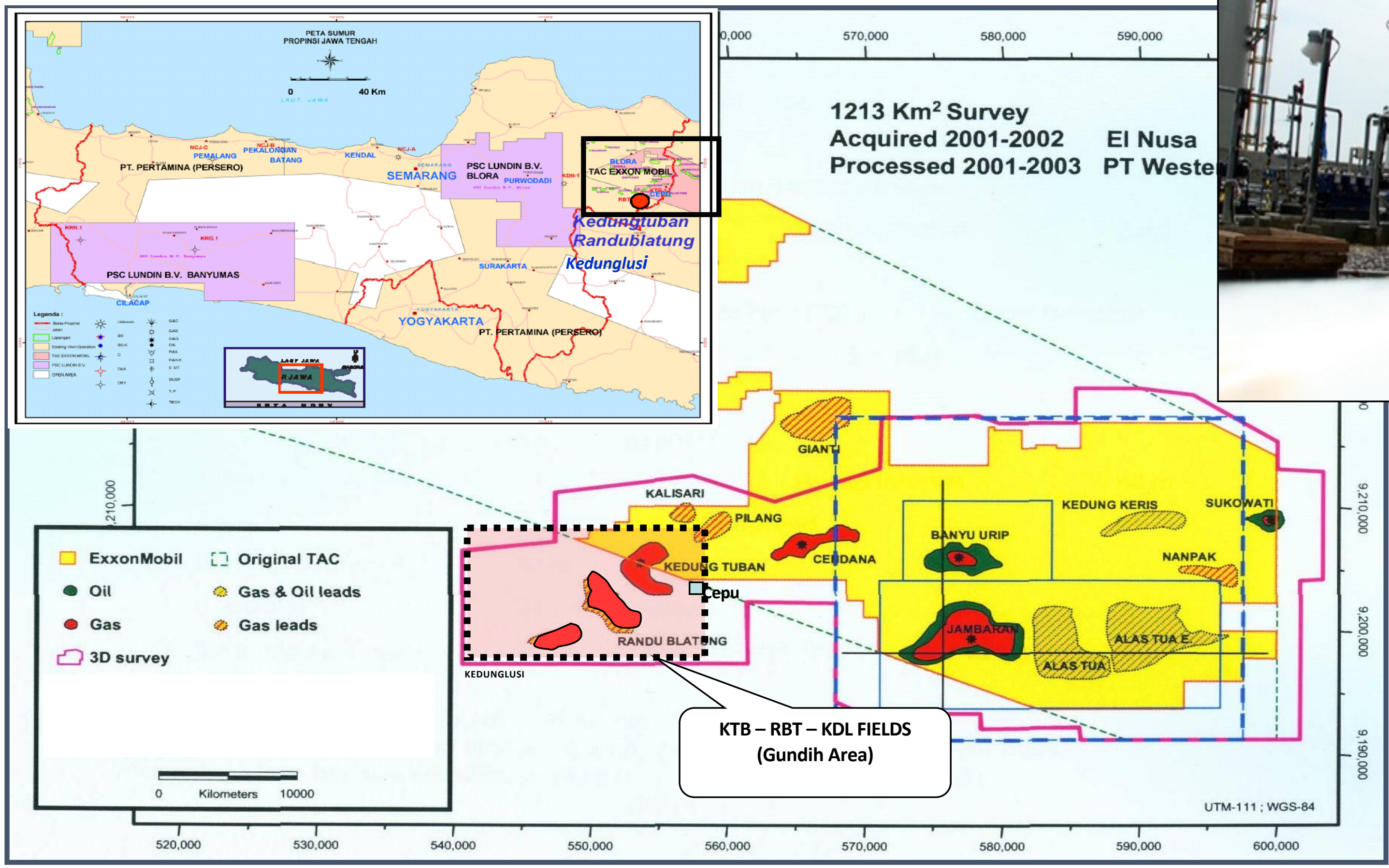
- The energy supply is getting more attentions.
- Some of oil fields in Indonesia becomes **mature and need EOR** (Enhanced Oil Recovery) treatments in future.
- Form environmental point of view, the **CO_2-EOR is attractive technology** since global warming gas (CO_2) is injected into the oil reservoir. However, it is required to develop the technologies of how to handle CO_2 for this purpose.

→ **CCS and CCUS implementations are not included in Indonesian NDC as the tool that could reduce the GHG emissions, because it was predicted that these technologies are too expensive.**

→ **The concept of CO_2-injection implementation in the form of CO2-EOR or CO_2-EGR are introduced by National CoE for CCS, CCUS since the end of 2019, when the preparation of the Gundih CCS project is revised to be the Gundih CCUS project**

When ITB start with CCS/CCUS? ITB activities on CCS/CCUS was started in 2012, when ITB (and Kyoto University) won SATREPS project (2012 – 2017)

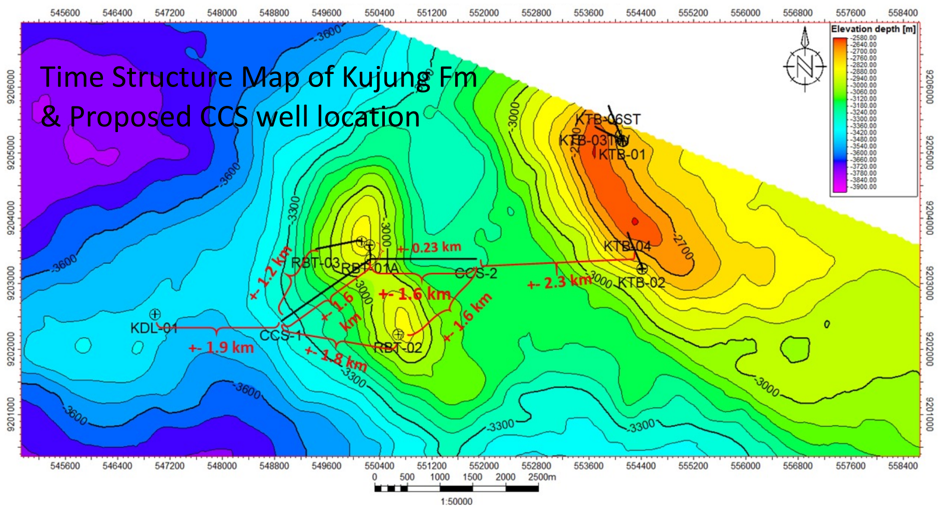
It was JPY 500 millions, 60% for ITB and 40% for Kyoto University



Research activities in the field

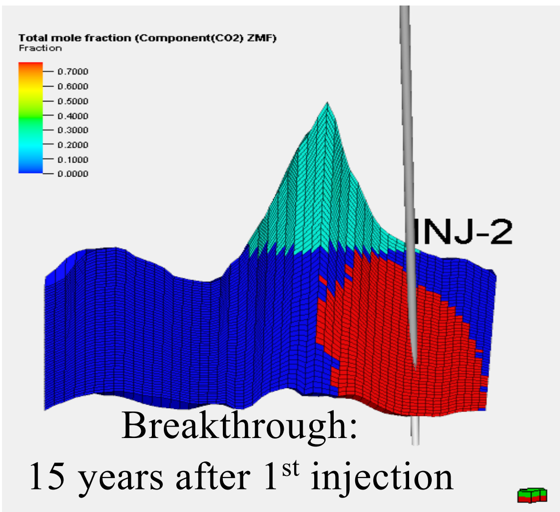
1. Provides guidance to the students before going to the field
2. Vibro being prepared before the action
3. Recording group in action (Labo)
4. DSS-12 recording system
5. GRS system
6. Geophone
7. DSS-12 warehouse

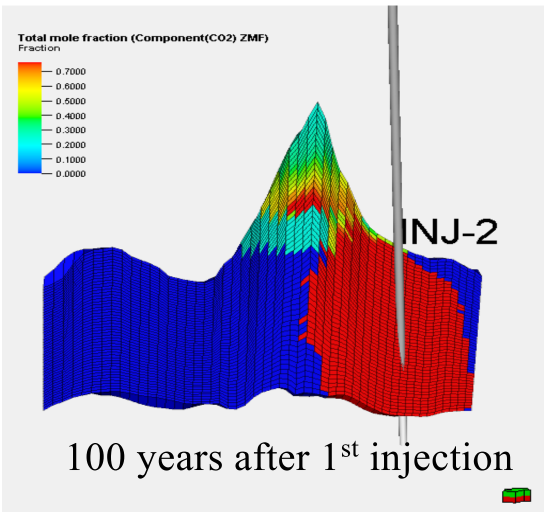
What we have learnt from the NEW Scenario (version 2021) of the Planned CCUS Project in GUNDIH AREA

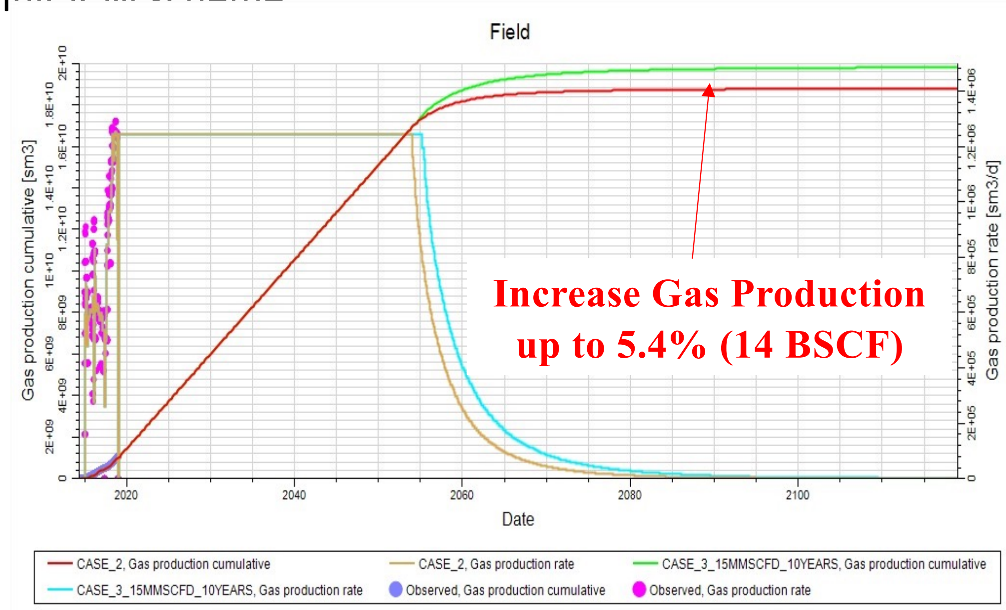


Currently Gundih CPP releases 800 tpd of CO2. If all of available CO2 is injected to Kedungtuban structure:

- 3 mio of CO2 will be reduced for 10 years injection time.
- Incremental gas production of 14 BSCF for 10 years, equivalent to approx. USD 60 mio.
- The Opex and Capex for 10 years CO_2 injection = USD 120 mio.
- Offering participation of foreign institutions for injecting CO2, e.g. using JCM scheme







CHALLENGES and Solution (?)

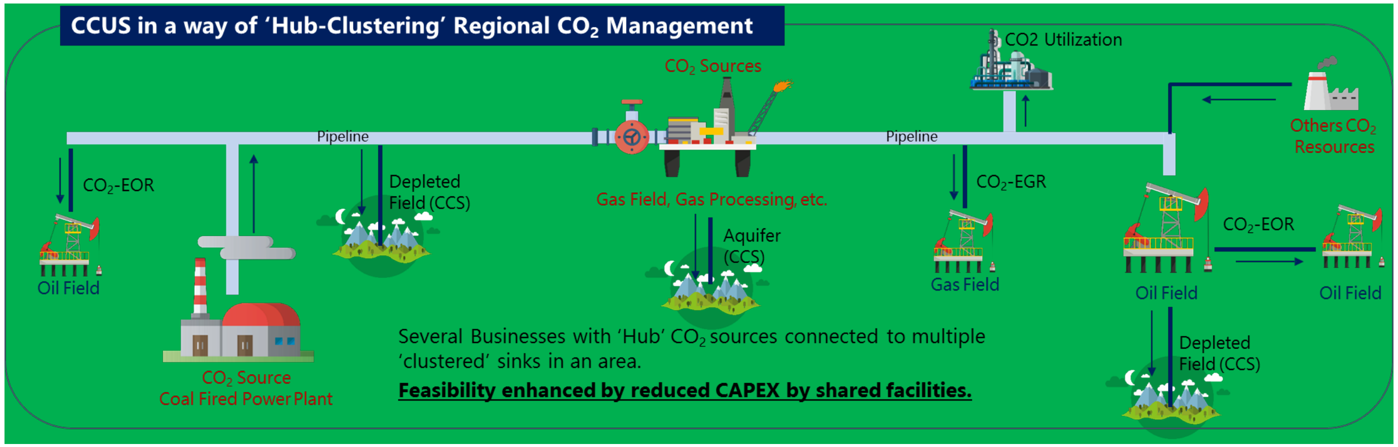
- ## Cost of CCS/CCUS

  ➢ **The highest cost of CCS/CCUS activities is for CO_2 Capture.**

CAPTURE	TRANSPORTATION	STORAGE
45.92 USD/tCO_2	0.95 USD/tCO_2	15.93 USD/tCO_2
73.12%	1.52%	25.36%

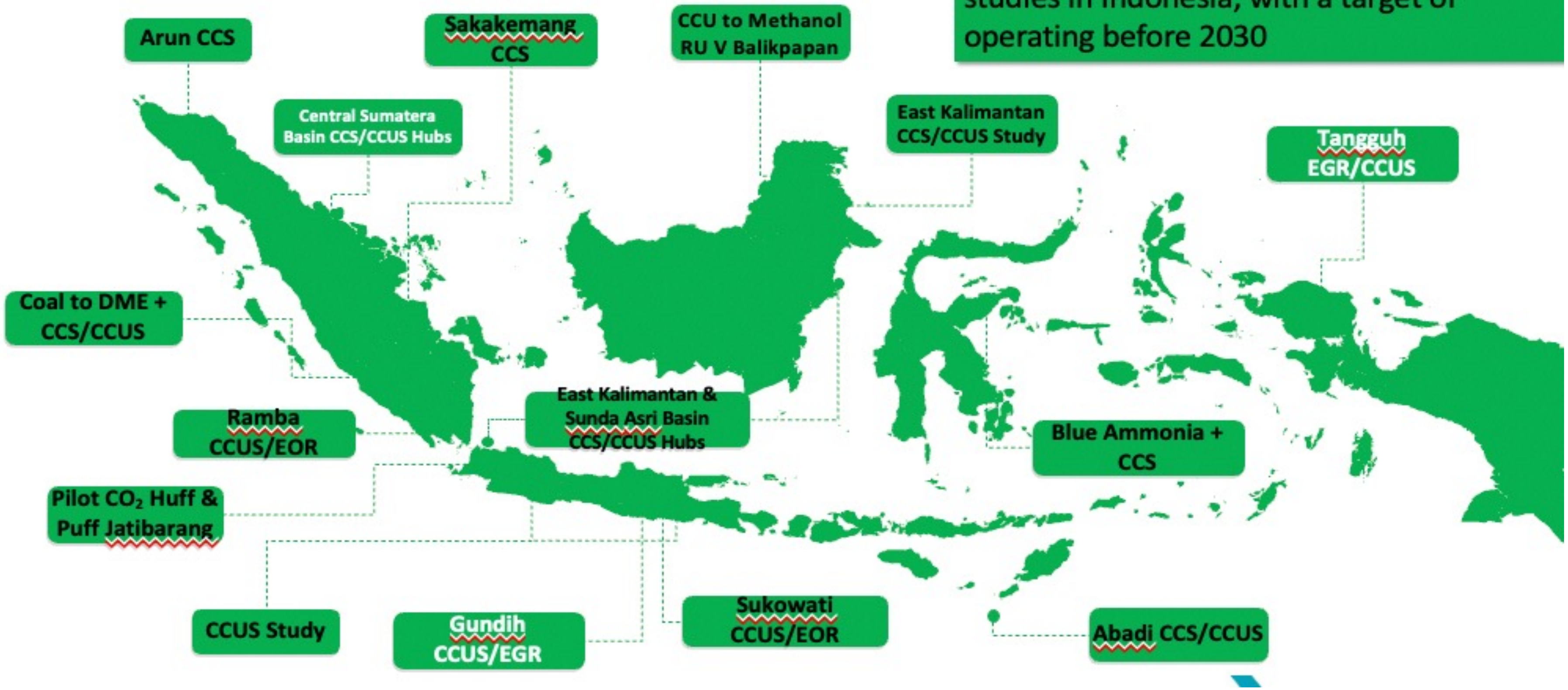
Source: Study on the Potential for Promoting Carbon Dioxide Capture, Utilisation, and Storage (CCUS) in ASEAN Countries Vol. II Asia CCUS Network – ERIA, 2022

  ➢ **How to Lowering the Cost**
    - Technology Development
    - Partnership (Cost Sharing)
    - CCS/CCUS Hubs
    - Incentives
    - etc.



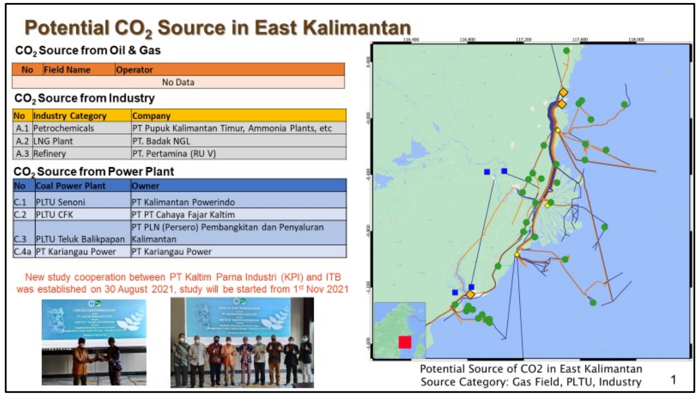
CCS/CCUS Project Status in Indonesia

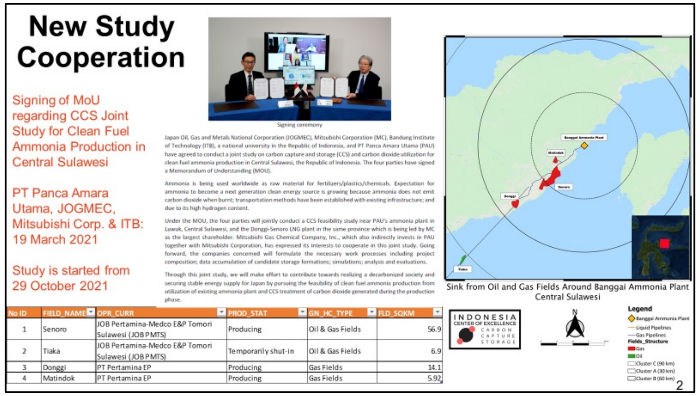
Currently there are 15 CCS/CCUS activity studies in Indonesia, with a target of operating before 2030



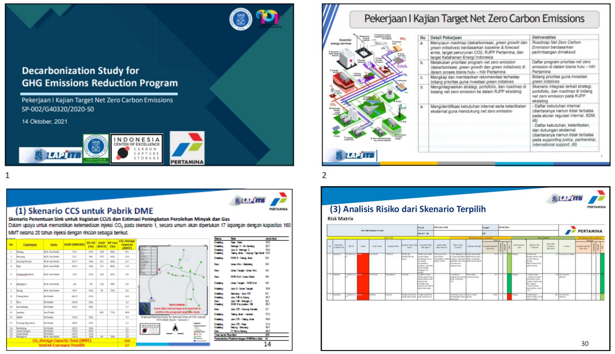
From those above lists, ITB's CoE participated in the 8 project

Current Studies/Projects conducted by ITB together with Industries and International Partners

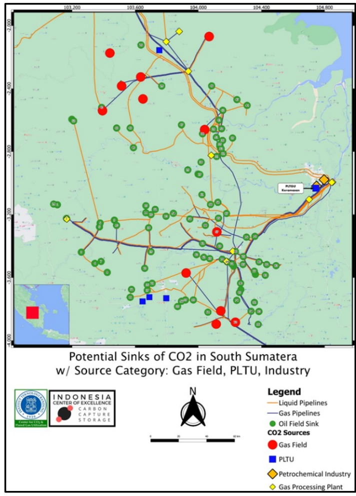


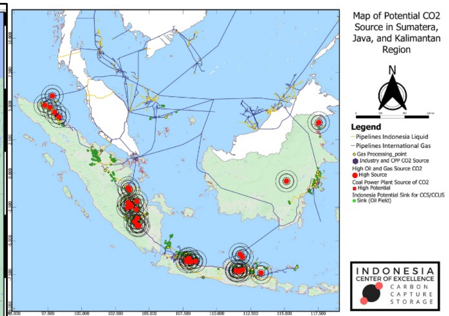


CCS Joint Study for Clean Fuel Ammonia in East Kalimantan and Central Sulawesi

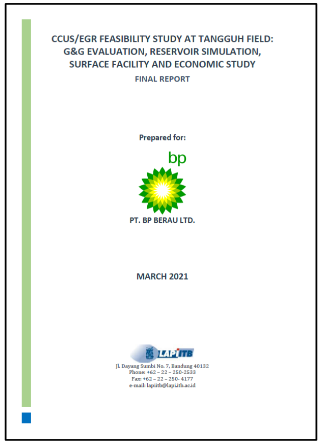


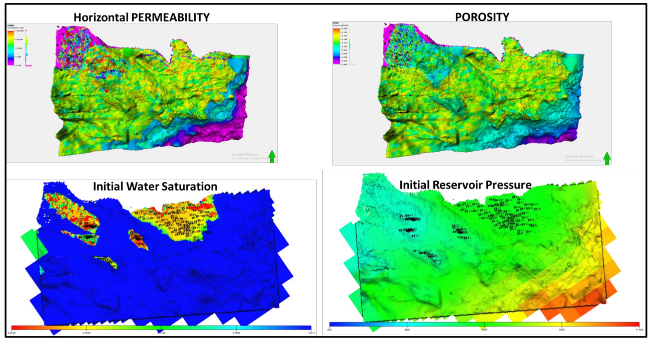
Decarbonization Study For Greenhouse Gases Emission Reduction Program





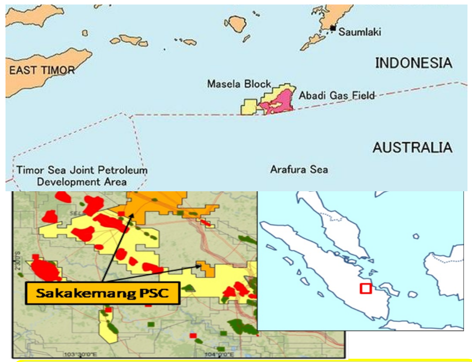
Indonesia CO_2 Source – Sinks Mapping and Spatial Database





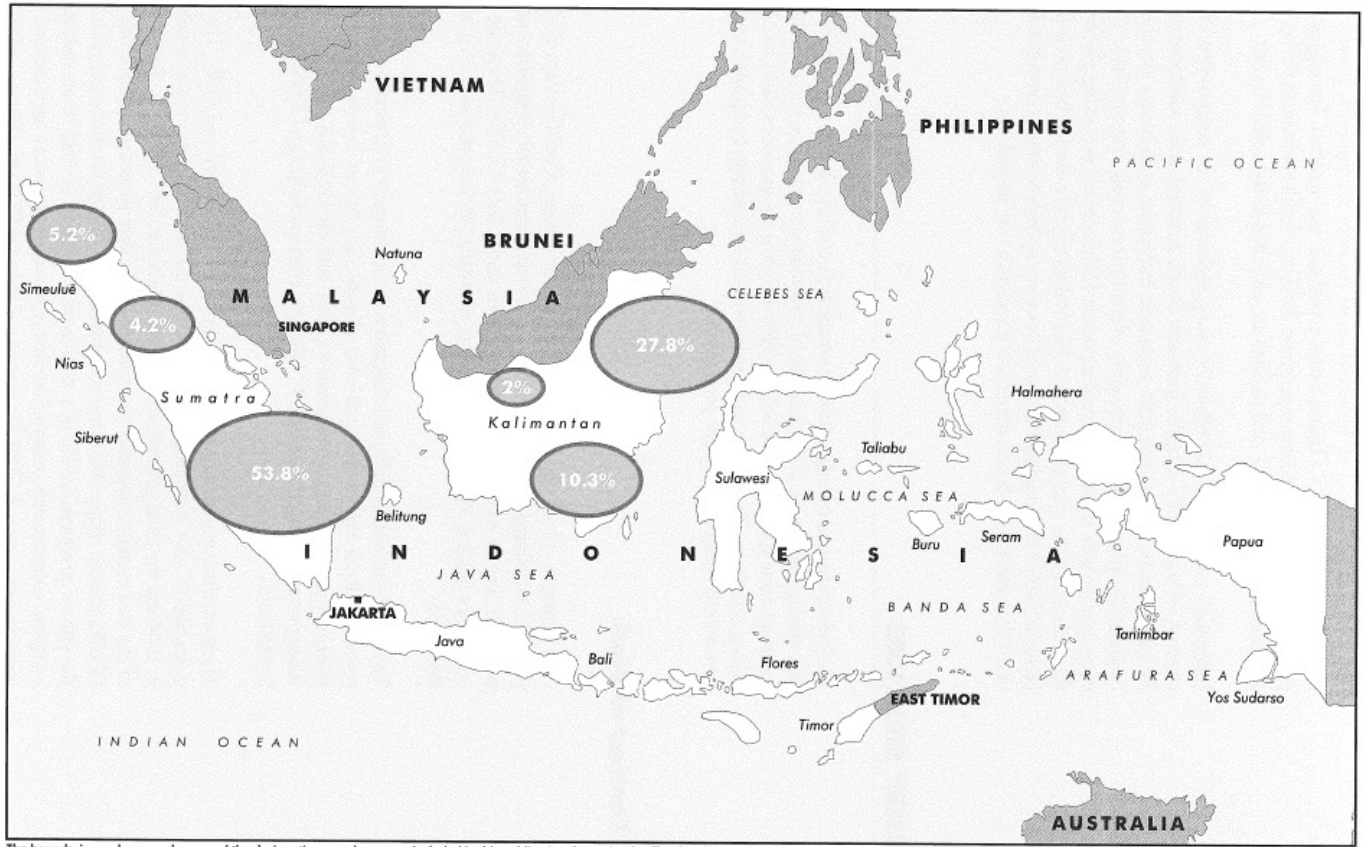
CCUS/EGR Feasibility Study At Tangguh Field:

G&G Evaluation, Reservoir Simulation, Surface Facility and Economic Studies



NEXT: Abadi & Sakakemang CCS Feasibility Study

Indonesia is a Coal Country



The boundaries and names shown and the designations used on maps included in this publication do not imply official endorsement or acceptance by the IEA.

Note: Some disparity in totals may occur due to rounding.

Source: Ministry of Energy and Mineral Resources.

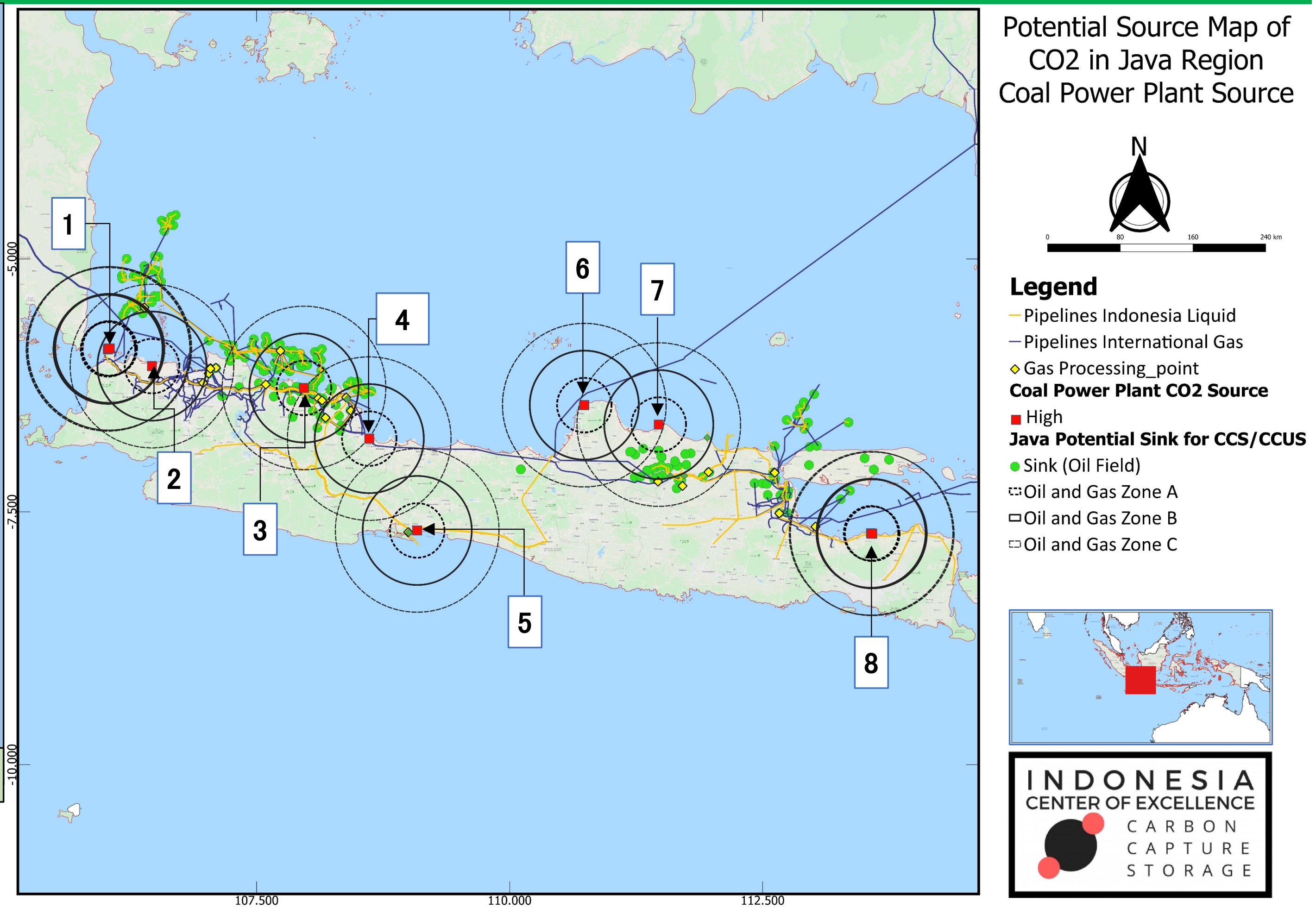
Decarbonisation of GHG from coal-fired power plants is also our main concern.

Overview of Potential CO2 Source Map from Coal-fired Power Plants in Java Region

CO_2 Source (According map, subject of discussion)

- Coal Power Plant (8 Plants)
  - PLTU Suralaya & PLTU LBE (1)
  - PLTU Lontar (2)
  - PLTU Indramayu (3)
  - PLTU Cirebon (4)
  - PLTU Cilacap (5)
  - PLTU Tanjung Jati B (6)
  - PLTU Rembang (7)
  - PLTU Paiton (8)

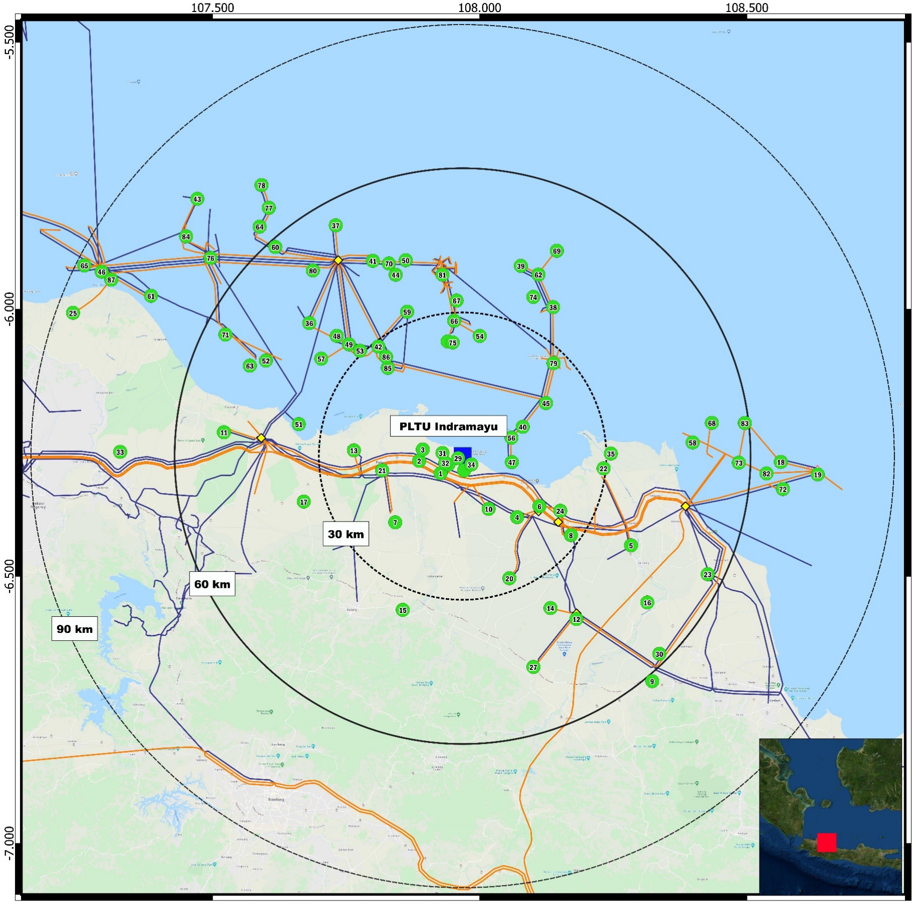
- Power Plant (coal) CO_2 is classified as:
  - Low: <1000000 TCO_2e
  - Medium: 1-2 million TCO_2e
  - **High: > 2 million TCO_2e**



The study is currently conducted between ITB and PLN (Des 2022 – Apr 2023)

Example of CO2-Hub in the vicinity of PLTU Indramayu (290 MW)

No ID	FIELD_NAME	Operator	PROD_STAT	GN_HC_TYPE
1	Karang Enggal	PT Pertamina EP	Producing	Oil & Gas Fields
2	Jati Asri	PT Pertamina EP	Producing	Oil & Gas Fields
3	Jati Sinta	PT Pertamina EP	Producing	Oil & Gas Fields
4	Kandang Haur Timur	PT Pertamina EP	Producing	Oil & Gas Fields
6	Cemara Barat	PT Pertamina EP	Producing	Oil & Gas Fields
7	Pegaden	PT Pertamina EP	Producing	Oil & Gas Fields
8	Cemara Selatan	PT Pertamina EP	Producing	Oil & Gas Fields
10	Kandang Haur Barat	PT Pertamina EP	Temporarily shut-in	Oil & Gas Fields
13	Bojongraong	PT Pertamina EP	Producing	Oil & Gas Fields
20	Gantar	PT Pertamina EP	Producing	Oil & Gas Fields
21	Pamanukan Selatan	PT Pertamina EP	Producing	Oil & Gas Fields
22	Waled Utara	PT Pertamina EP	Producing	Oil & Gas Fields
24	Cemara Timur	PT Pertamina EP	Producing	Oil & Gas Fields
26	Melandong	PT Pertamina EP	Producing	Oil & Gas Fields
28	Karang Baru	PT Pertamina EP	Producing	Oil & Gas Fields
29	Tegal Taman	PT Pertamina EP	Producing	Oil Fields
31	Karang Baru Barat	PT Pertamina EP	Temporarily shut-in	Oil & Gas Fields
32	Karang Tunggal	PT Pertamina EP	Temporarily shut-in	Oil & Gas Fields
34	Jati Keling	PT Pertamina EP	Producing	Oil & Gas Fields
40	Arjuna FS	PT Pertamina Hulu Energi ONWJ Ltd	Temporarily shut-in	Oil & Gas Fields
42	Arjuna U	PT Pertamina Hulu Energi ONWJ Ltd	Producing	Oil & Gas Fields
45	Arjuna FF	PT Pertamina Hulu Energi ONWJ Ltd	Temporarily shut-in	Oil & Gas Fields
47	Arjuna FZ	PT Pertamina Hulu Energi ONWJ Ltd	Producing	Oil & Gas Fields
54	Arjuna ESR	PT Pertamina Hulu Energi ONWJ Ltd	Producing	Oil & Gas Fields
55	Arjuna ESS	PT Pertamina Hulu Energi ONWJ Ltd	Producing	Oil & Gas Fields
56	Arjuna FSW	PT Pertamina Hulu Energi ONWJ Ltd	Producing	Oil & Gas Fields
66	Arjuna ES	PT Pertamina Hulu Energi ONWJ Ltd	Producing	Oil & Gas Fields
75	Arjuna EST	PT Pertamina Hulu Energi ONWJ Ltd	Temporarily shut-in	Oil & Gas Fields
79	Arjuna F	PT Pertamina Hulu Energi ONWJ Ltd	Producing	Oil & Gas Fields
85	Arjuna UB	PT Pertamina Hulu Energi ONWJ Ltd	Producing	Oil & Gas Fields
86	Arjuna UY	PT Pertamina Hulu Energi ONWJ Ltd	Producing	Oil & Gas Fields



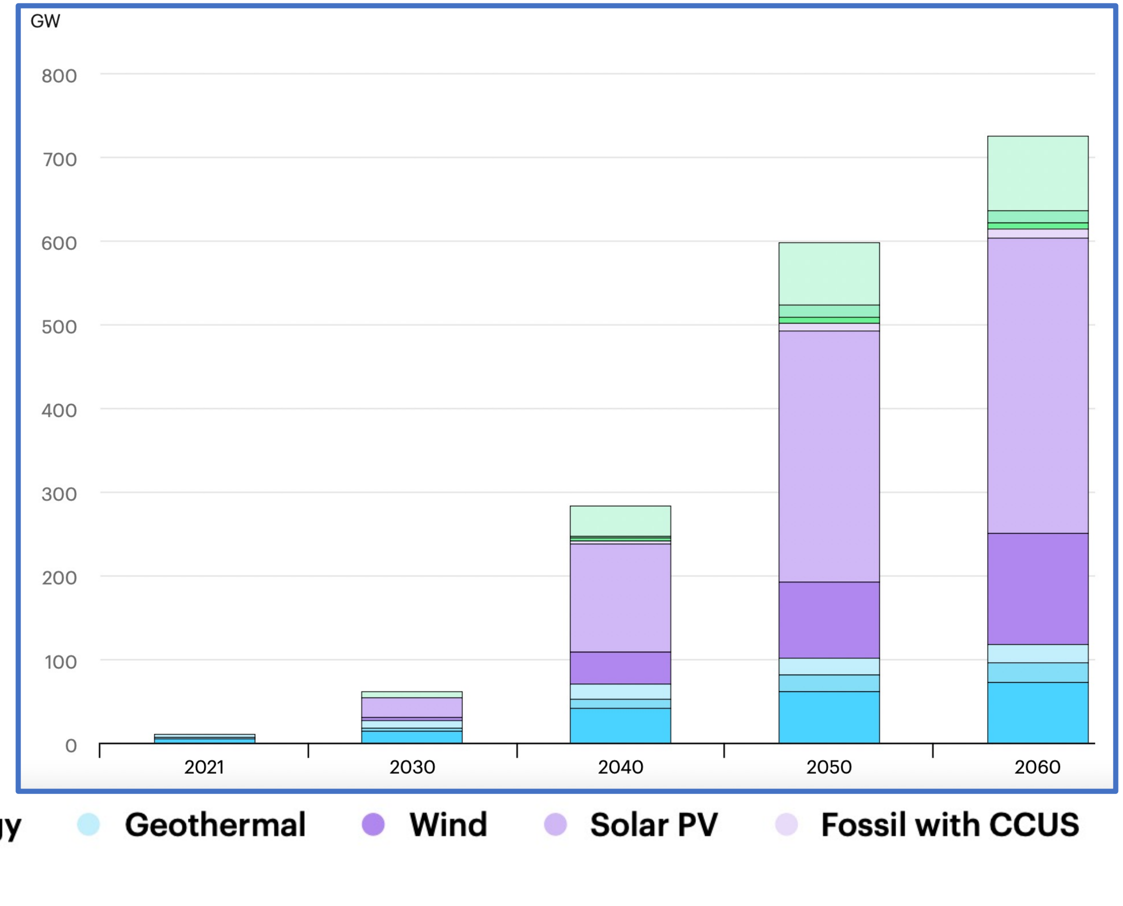
Sink from Oil Fields Around PLTU Indramayu
West Java

INDONESIA CENTER OF EXCELLENCE CARBON CAPTURE STORAGE

Legend
- Coal Power Plant
- Gas Processing_point
- Liquid Pipelines
- Gas Pipelines
- Sink (Oil Field)
- Cluster A (30 km)
- Cluster B (60 km)
- Cluster C (90 km)

The study is currently conducted between ITB and PLN (Des 2022 – Apr 2023)

Installed electricity generation capacity for low emissions sources in Indonesia in the Announced Pledges Scenario, 2021-2060 (IEA, 2023)

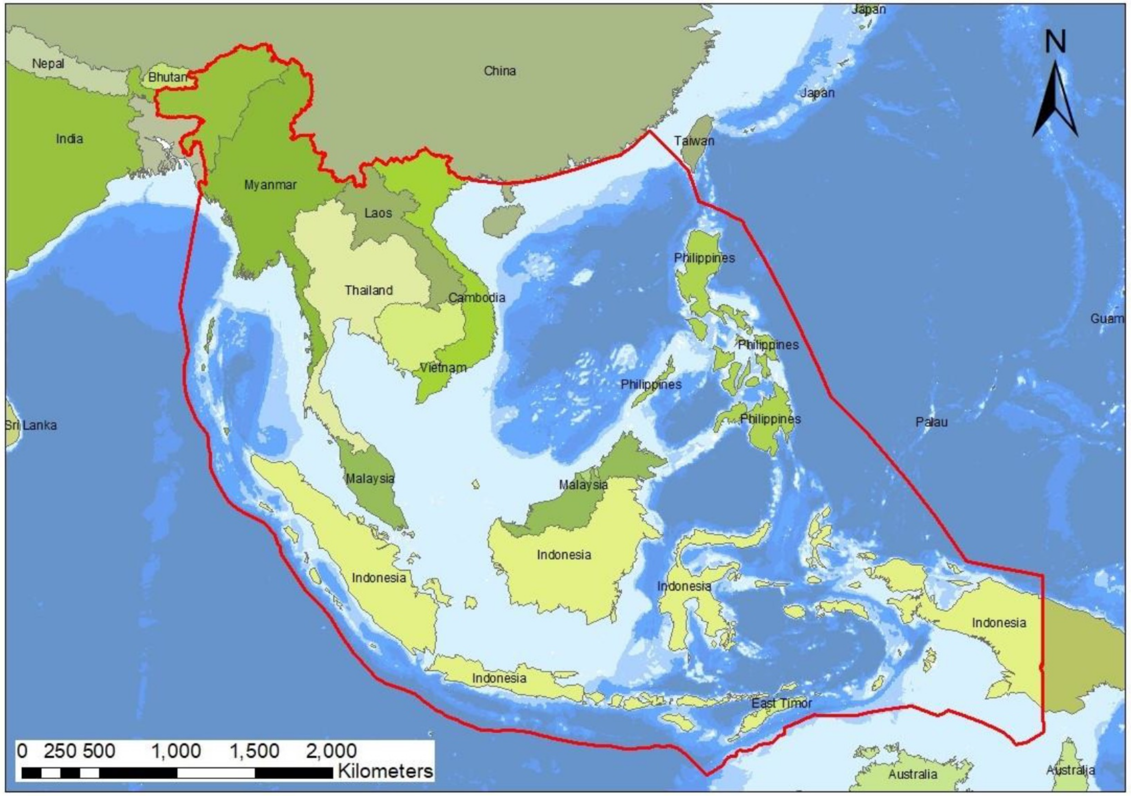


Regional Study of CO2 Storage Capacity in Saline Aquifer in Southeast Asia (March 2023)

Overview

- Study Area : Southeast Asia
- CCS Target : Saline Aquifer
- Database : Neftex® Predictions
- Study Term : October 2021～ March 2022
- Study Objective:

  Screening of Suitable Areas for CCS Using Neftex® Predictions



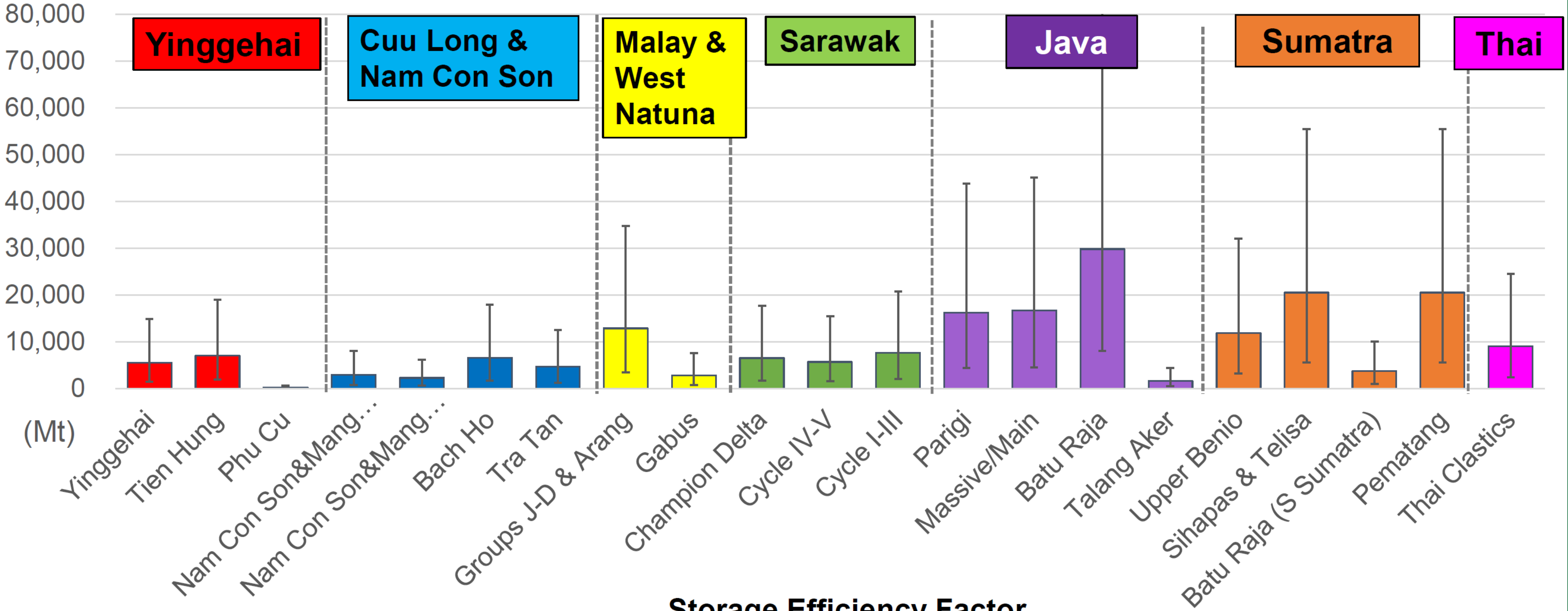
JOGMEC HALLIBURTON

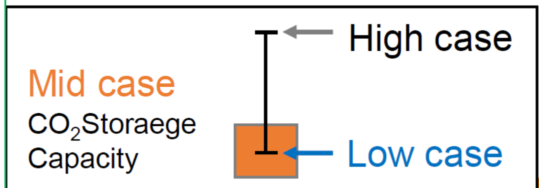
Estimation Result

JOGMEC Proprietary

Phase 2 Results : Comparison of CO2 storage in each formation

JOGMEC 26



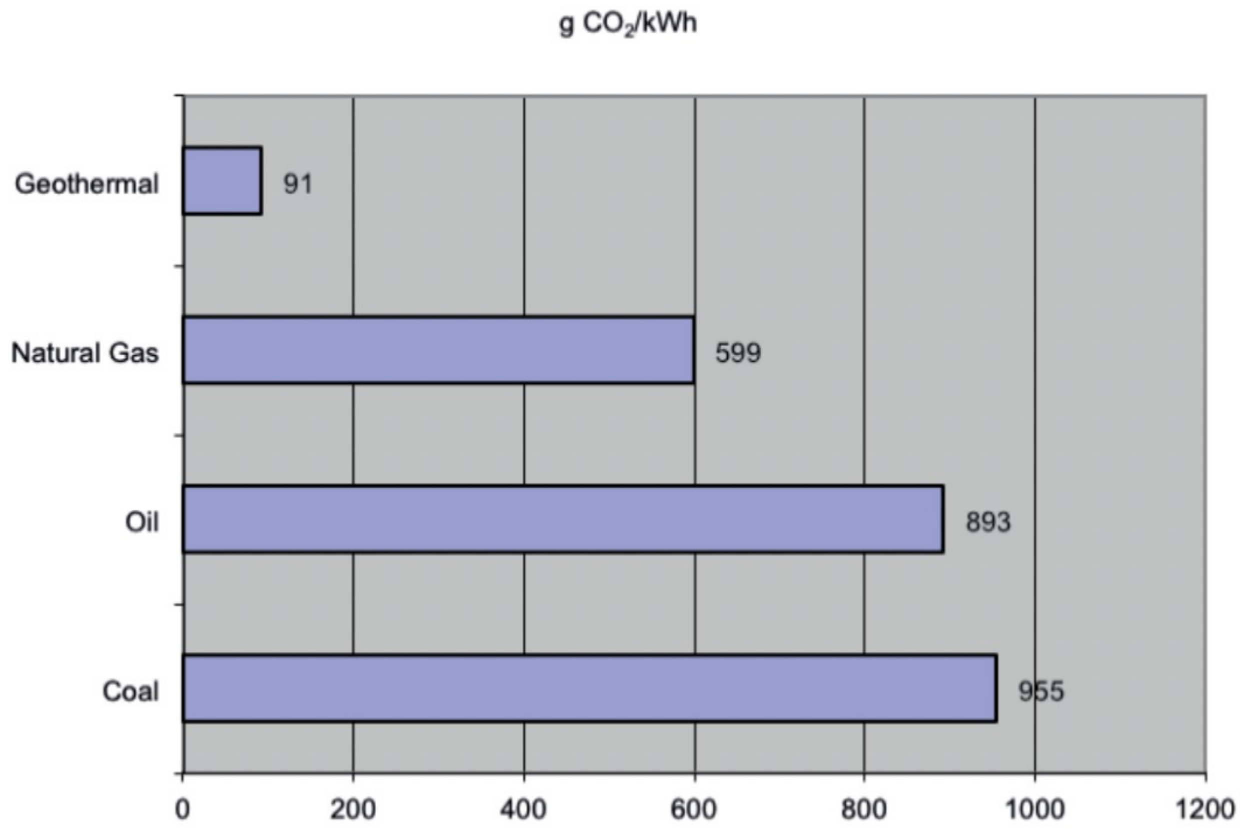


Storage Efficiency Factor

Low	Mid	High
0.51%	2.0%	5.4%

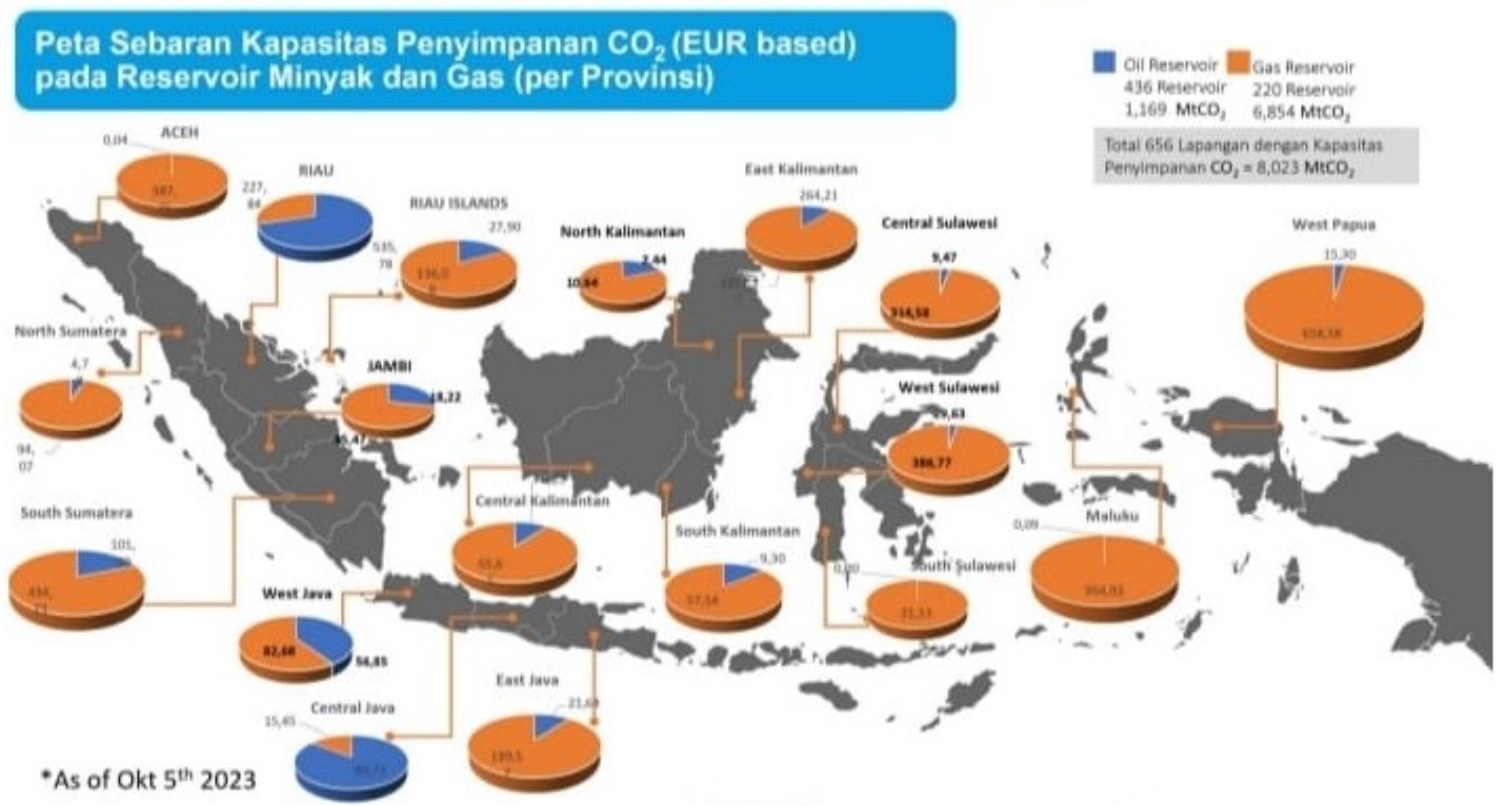
※Rough estimate

Comparison of CO_2 emissions from electricity generation in the USA (Bloomfield, et al., 2003)

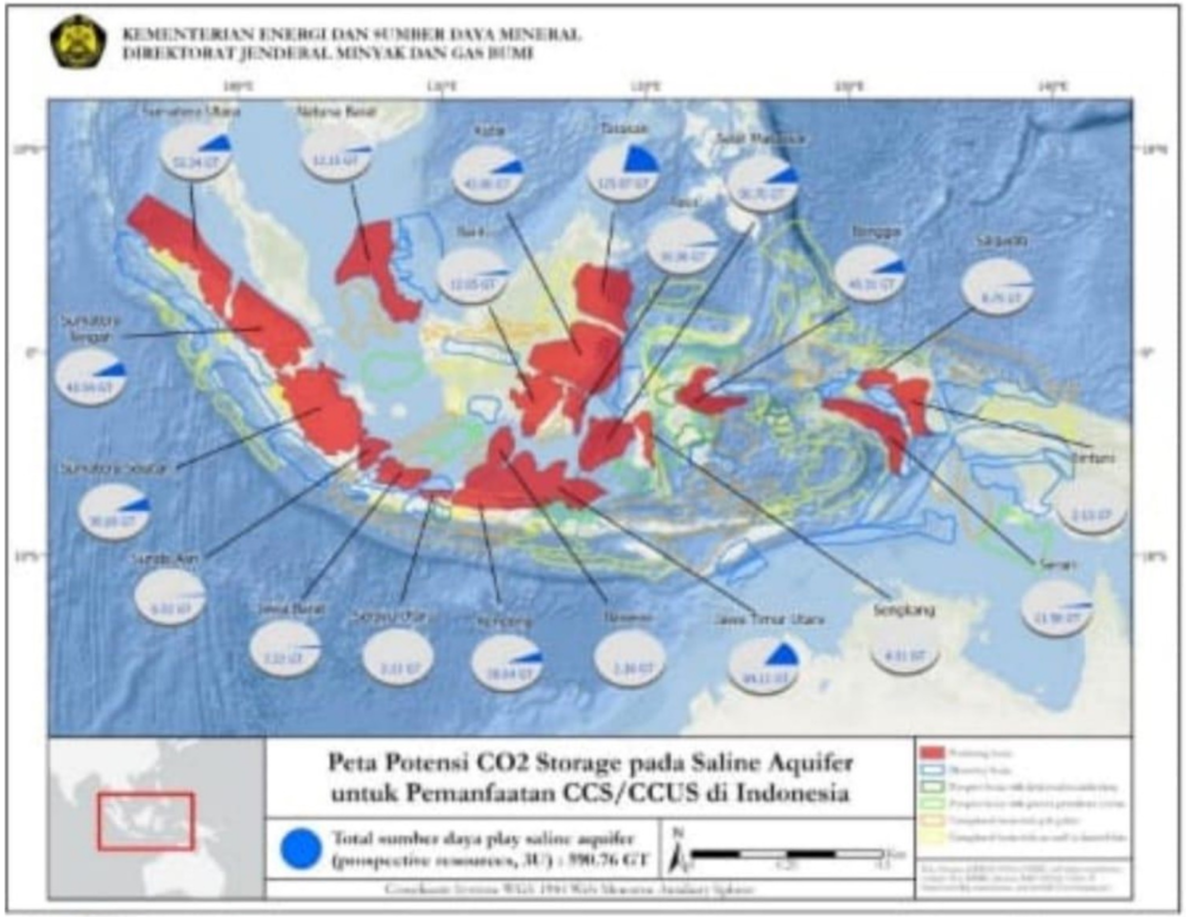


Storage capacity of oil and gas reservoir in Indonesia (Lemigas, 2023)

→ LEMIGAS's storage capacity in oil and gas reservoirs (version October 2023)



Prospective Storage Resources in Saline Aquifer in Indonesia(KESDM, 2023)



Peta penyebaran sumberdaya Play penyimpanan CO_2 (Prospective Storage Resources, 3U) pada saline aquifer skala Cekungan pada 20 Cekungan Produksi di Indonesia

Total sumberdaya Play Penyimpanan CO_2 (Prospective Storage Resources, 3U) : **590.76 GT**

Perlu diupdate secara berkala

Kementerian ESDM
Republik Indonesia

CO_2 Sources from Main Energy Sector in Indonesia

Indonesia target for GHG emission reduction from energy sector from 2010 - 2030 (20 years): ~ 314 - 398 Mt of CO_2

Gundih Field	3 Mt of Cumulative Total CO_2 that could be injected in 10 years
Tangguh Field	25 Mt of Cumulative Total CO_2 that could be injected in 10 years
Eastern Java	35 Mt of Cumulative CO_2 that could be produced from main oil and gas fields in Eastern Java for 10 years
Banggai Ammonia Plant & East Kalimantan Ammonia Plant	30 Mt of Cumulative CO_2 that potentially to be injected for 10 years
DME Project Tanjung Enim	40 Mt of almost pure CO_2 that potentially produced from coal gasification for 10 years and another 25 Mt of CO_2 from boiler incl. impurities

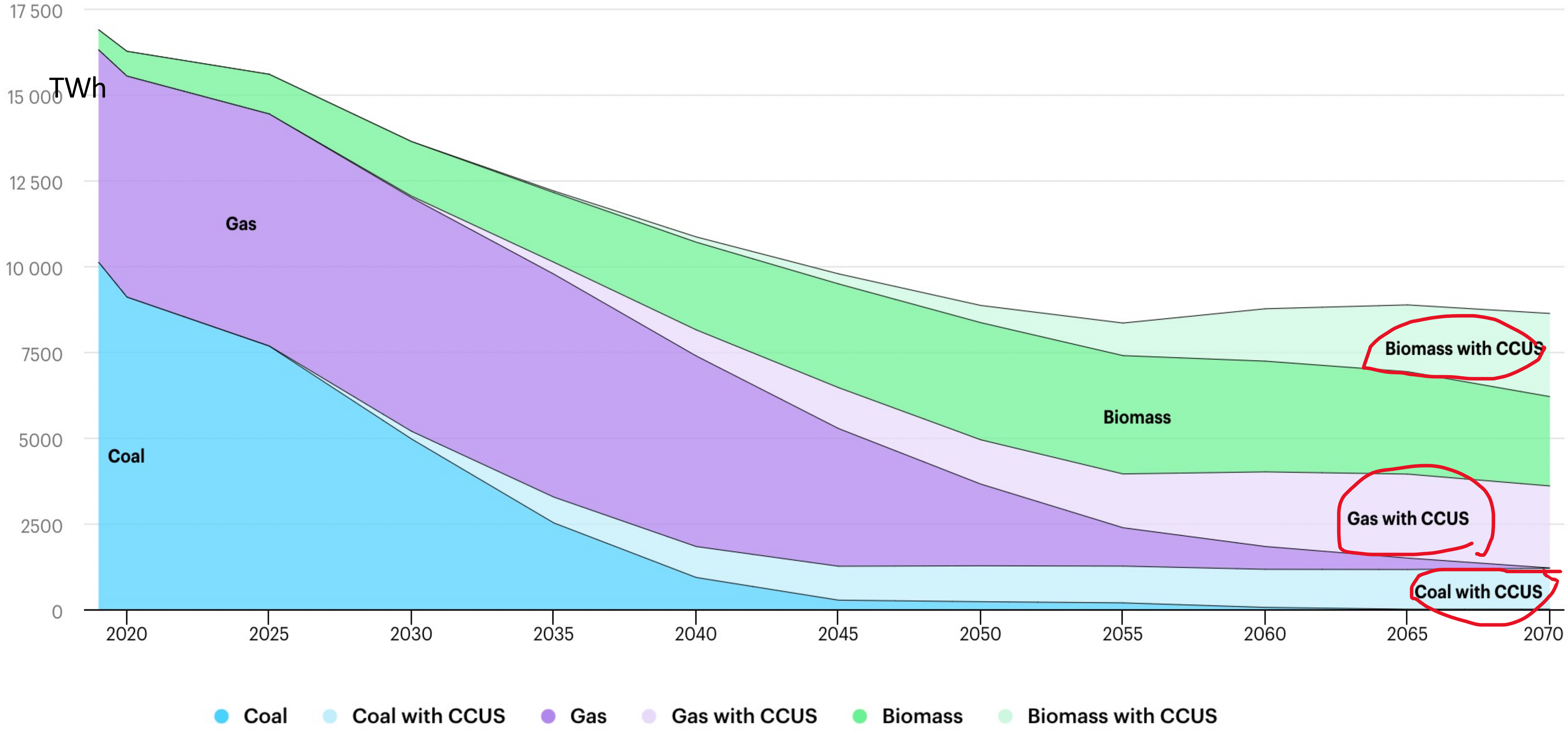
Potential of GHG reduction from these planned projects (10 years): ~ 137 Mt of CO_2

This is equal to 34 - 44% of GHG emission reduction target from energy sector (2010 - 2030)

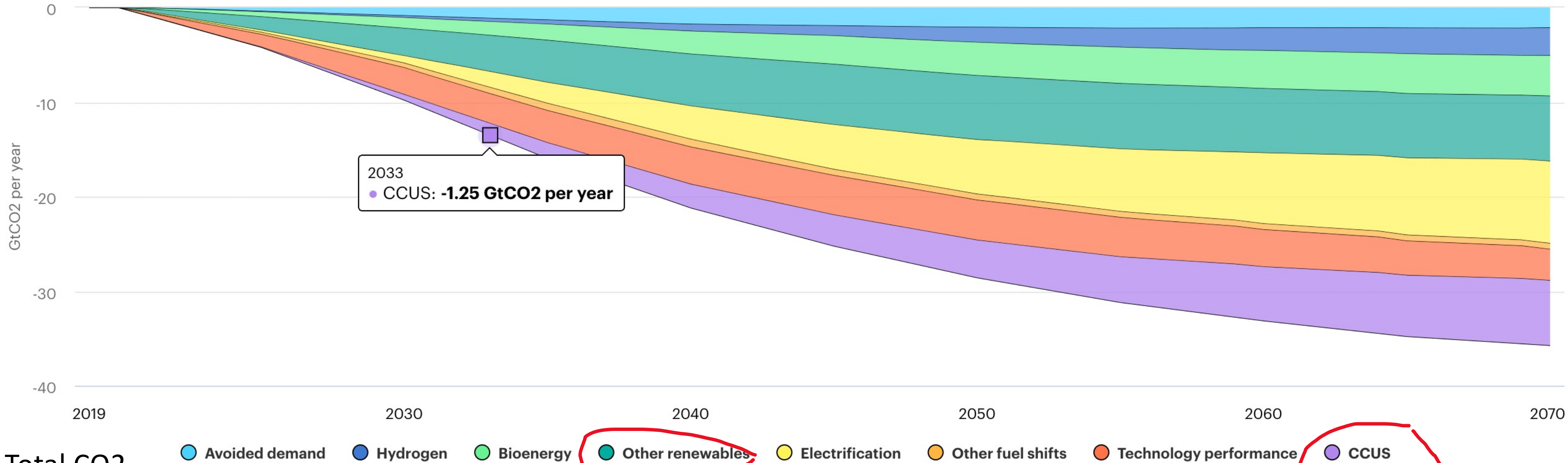
Potential CO_2 from the Coal-fired Power Plants	CO_2 released from all Coal-fired power plants in Indonesia (totally 35 GW, 80% capacity factor) ± 250 Mt of CO_2 p.a.

CCS/CCUS can play an important role in Indonesia, since there are a lot of CO_2 sources from energy sector and their locations are close enough to depleted oil reservoirs and coal mining

World electricity generation from plants equipped with carbon capture by fuel in the Sustainable Development Scenario, 2019-2070 (IEA, 2023)



CCUS Role to CO_2 emissions reductions in the energy sector in the Sustainable Development Scenario relative to the Stated Policies Scenario (IEA, 2023)



Total CO2 Reduction 35.12 GT

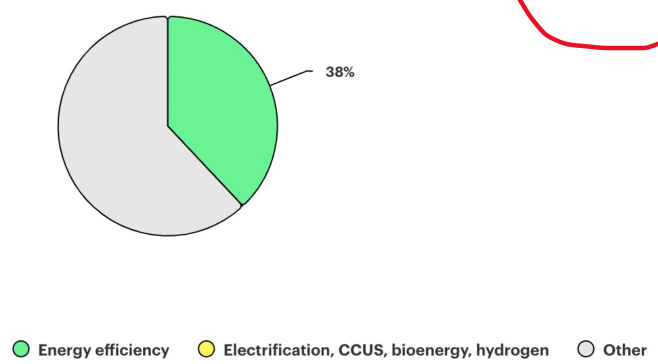
8,42%

12,18%

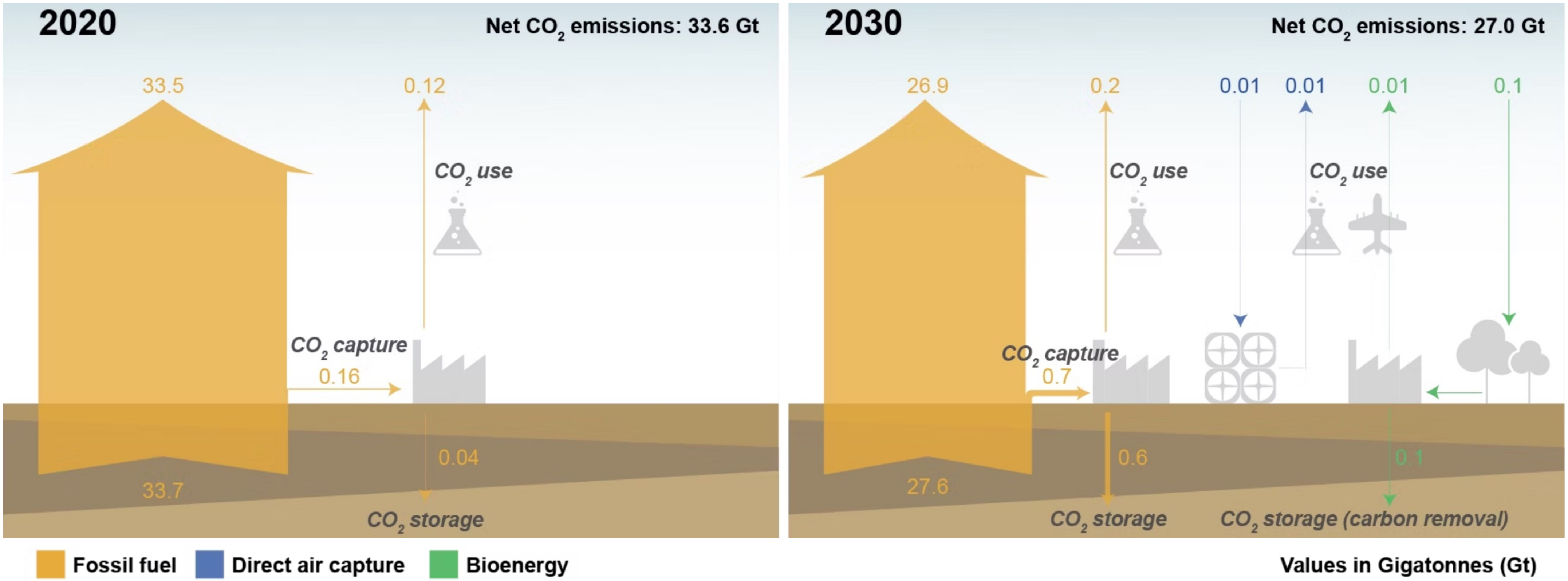
19.61%

25%

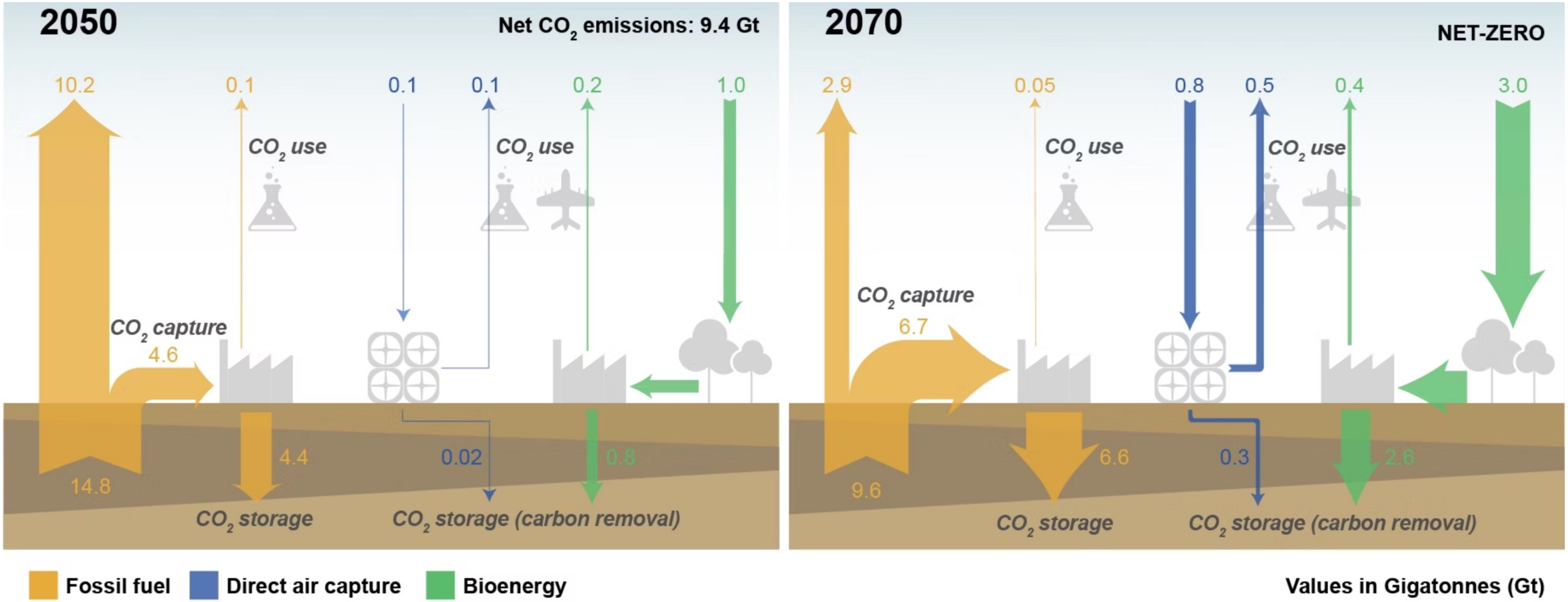
19.61%



CO_2 Emission Capture & Removal in SDG Secenario 2020-2030 (IEA,2023)

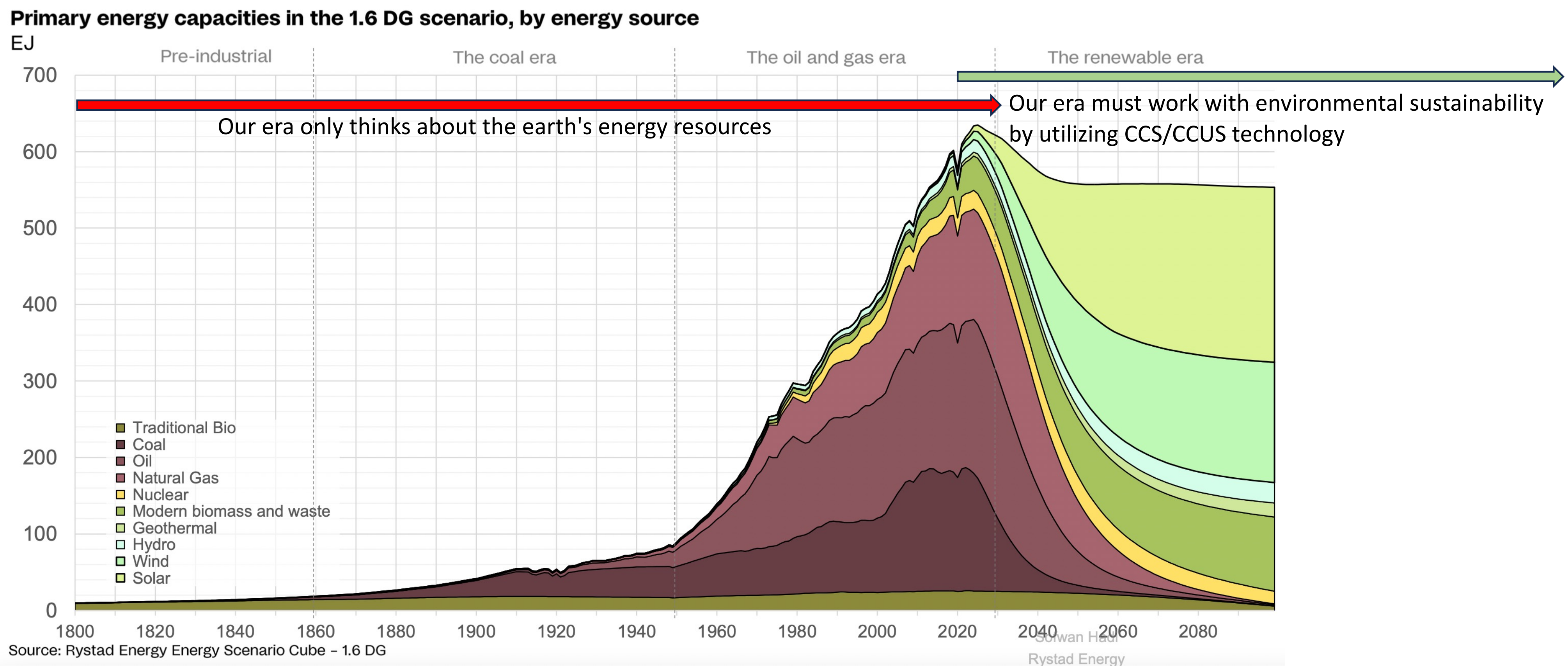


CO_2 Emission Capture & Removal in SDG Secenario 2050-2070 (IEA,2023)



Closing

Four eras of energy in modern time – all triggered by technological shift (modify from Rystad, 2023)



Thank you