# Assessment of Nuclear Cogeneration System for Coal Liquefaction

Sudi Ariyanto, Erlan Dewita, Djati Husein Salimi,
Siti Alimah and Dedi Priambodo
Center for Nuclear Energy Systems
National Nuclear Energy Agency (BATAN)
Email: asudi@batan.go.id

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# INTRODUCTION

# Introduction

- The electricity demand in Indonesia is projected to reach 115 GWe by 2025 and 430 GWe by 2050 – from current installed capacity of 42 GWe.
- Nuclear has been included as part of the new and renewable energy (NRE) options in the national energy mix strategy,

# Policy for New & Renewable Energy

*"Priority on the supply and utilization of new and renewable energy"*

1. **ENERGY CONSERVATION** to increase efficiency of energy usage in the supply and demand side, including industrial, transportation, household, and commercial sector.

2. **ENERGY DIVERSIVICATION** to increase new and renewable energy share in the national energy mix (***Supply Side***), in the form of

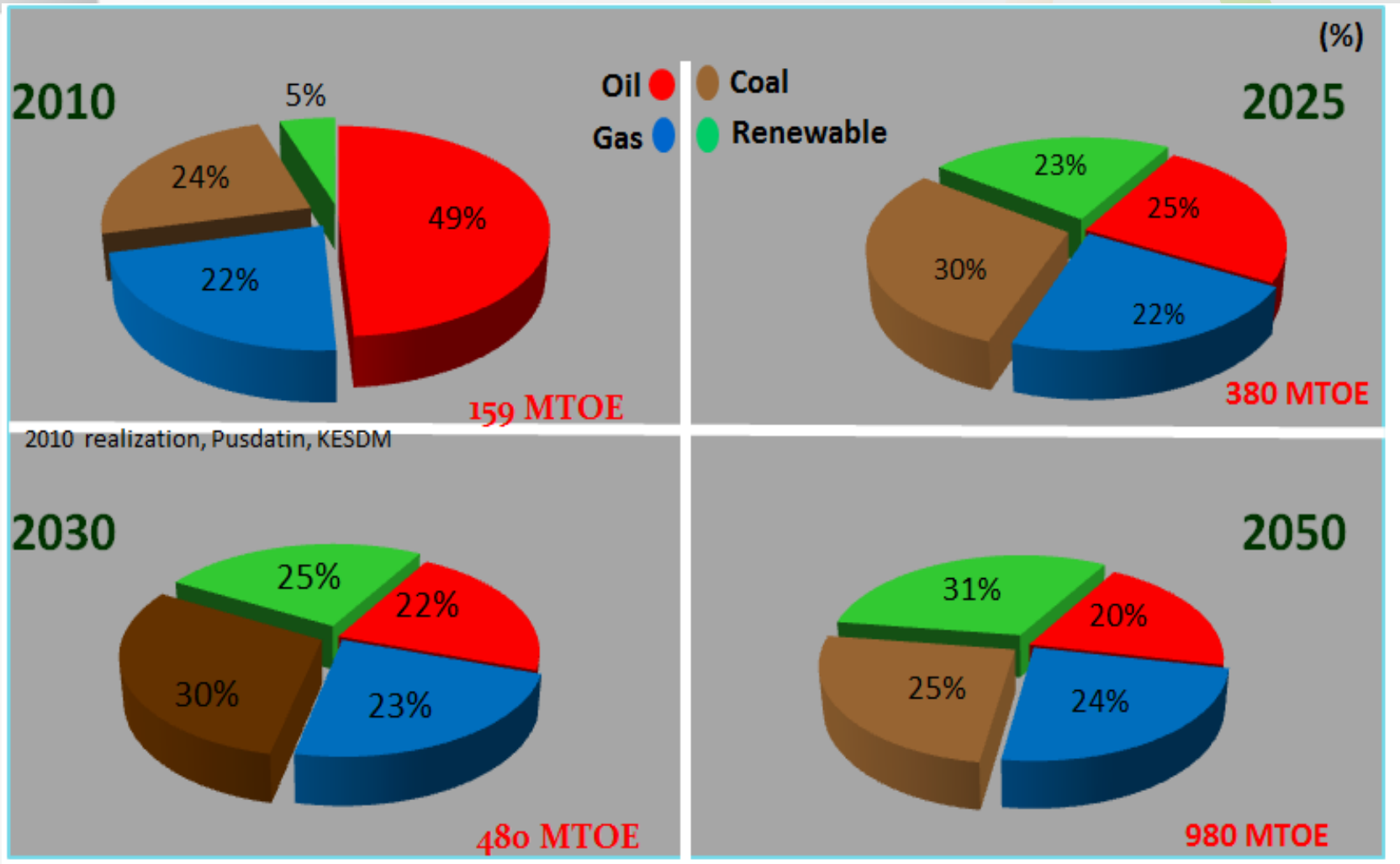
**New Energy**

a. Liquefied Coal
b. Coal Bed Methane
c. Gasified Coal
d. Nuclear
e. Hydrogen
f. Other methane

**Renewable Energy**

a. Geothermal
b. Hydro stream and waterfall,
c. Bioenergy,
d. Solar,
e. Wind,
f. Ocean Movement and Layer Temperature Difference

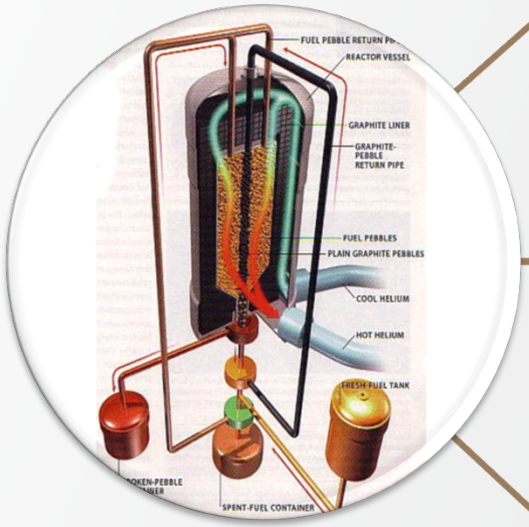
# Energy Condition



# National Action Plan

- Ministry of Energy and Mineral Resources
  - Accelleration program for nuclear energy utilization
  - 5000 Mwe in 2024
- BATAN
  - Experimental power reactor to demonstrate electricity production and to support new and renewable enerby

# EPR BENEFIT (GENERAL)




EPR

- **Electricity** — EPR will produce electricity for BATAN Puspiptek area (temporary substitution of installed capacity)
- **Heat Application Process** — EPR will be used for research of heat application process at temperature >800°C (hydrogen production, liquefaction / gasification of coal, etc).
- **R&D for HTGR Technology** — R & D related to HTGR Technology for development of design and construction of Indonesia HTGR.

# BENEFIT

- Supporting the implementation of national program for development of renewable energy as part of national energy mix
- Increasing the capacity of national industry in the fields of manufacturing, civil construction and services in support of the nuclear industry in Indonesia.

# BENEFIT

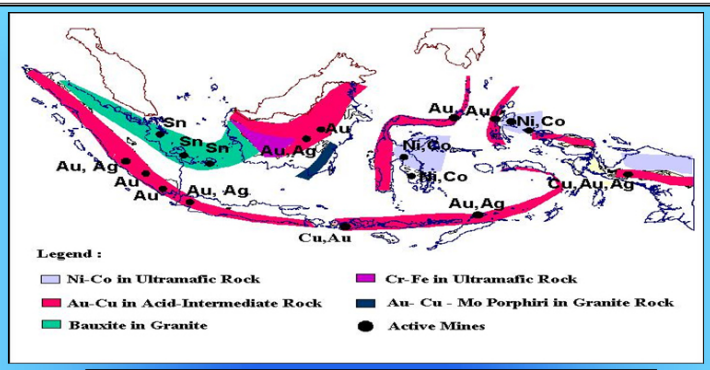
- Enhancing public acceptance of nuclear technology, especially nuclear power plants.
- EPR will be developed as a master HTGR for commercial deployment for electricity production heat applications for industry

# General Specification of EPR

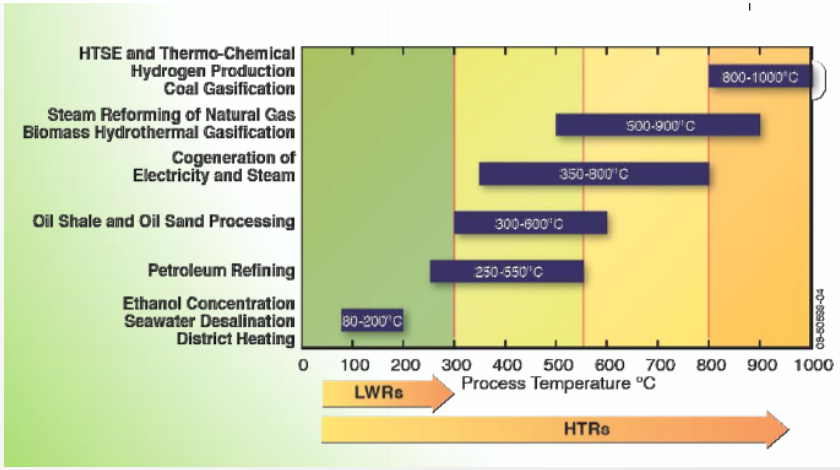
- Reactor Power : 10-20 MW
- Type : HTGR
- Fuel : Triso
- Output : **Electricity (3-7 MWe),**
  Co-generation (>800 °C),
  Available for Experimental Facilities stage-1
- Operation Mode: In line with the Experimental Needs
  (electricity, co-generation, *inherent safety*)
- Life time : 20 Years

# PROSPECT OF EPR DEVELOPMENT

## Indonesian Mineral Resources



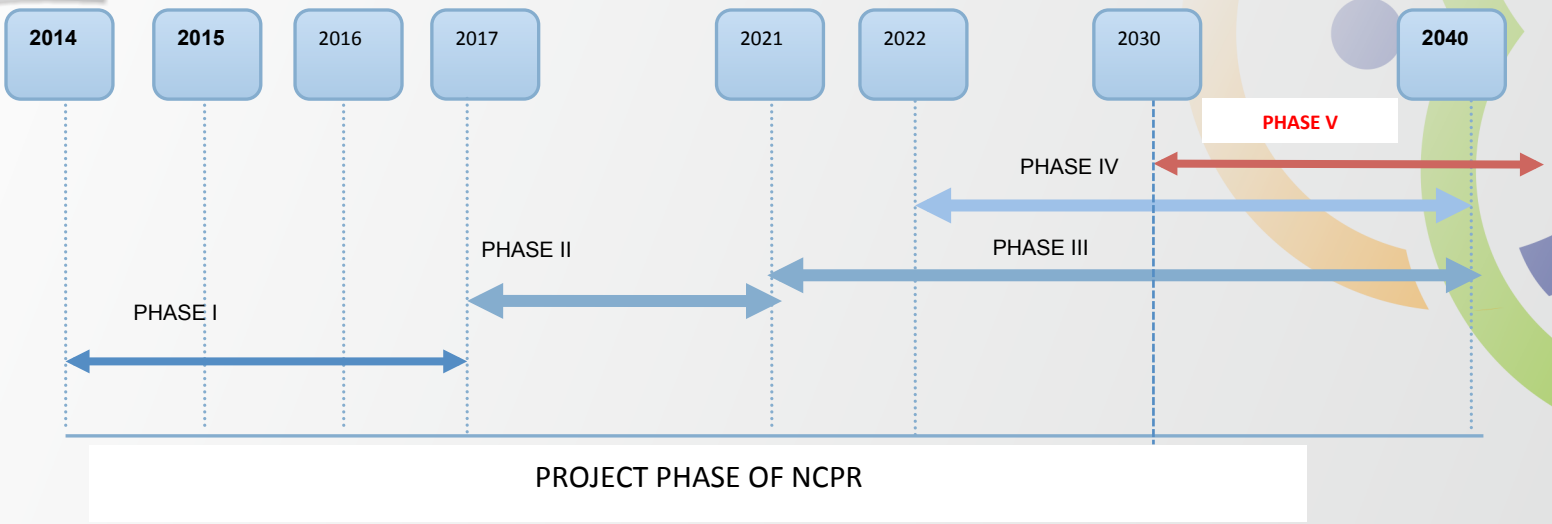

| No | COMMODITIES | RESERVES 2005 | RESOURCES 2005 | PRODUCTION 2006 | RESOURCES 2006 | NOTE |
|---|---|---|---|---|---|---|
| 1 | Nickel | 1,681,655,200 | 437,504,950 | 4,354 (ore, 000 wmt) | 435,788,715 | Ore |
| 2 | Tin | 627,649 | 455,915 | 65,000 (tons) | 388,939 | Metal |
| 3 | Bauxite | 579,536,760 | 73,853,546 | 1,502,000 (mt) | 72,771,807 | Ore |
| 4 | Copper | 68,960,881 | 32,738,682 | 818,000 (dmt) | 31,784,561 | Metal |
| 5 | Primary Gold | 4,240 | 3,445 | 143 (tons) | 3,325 | Metal |
| 6 | Silver | 508,168 | 13,601 | 326.99 (tons) | 13.31 | Metal |
| 7 | Iron Sand | 165,075,794 | 4,732,000 | 5,000 (tons) | 4,707,725 | Ore |




- **Electricity Production 10-300 MWe/unit**
- **Co-generation (NRE Development)**
  - hydrogen Production and Coal Liquefactiobn
  - *Steam reforming natural gas*
  - Hydrothermal Gasification of biomass
  - *Oil shell and Oil sand processing*
  - *Petroleum Refining*
  - Ethanol Concentration
  - Seawater desalination
  - Smelter
- Utilization of Thorium as a nuclear fuel

Commercial utilization

# Project Phase




Phase I Pre-Project: 2014-2016

Phase II EPC Project (*Engineering, Procurement, Construction* / EPC)/ Turnkey Project (*Engineering, Procurement, Construction* / EPC): 2017-2021

Fase III Commissioning and operation of NCPR , Experiment Activities: 2021-2040

Phase IV Phase of development for integrated NRE research (co-generation) and heat application laboratory : 2022-2040

Phase V Deployment of NPP , commercialization based on EPR (2030-2060)

HQ BATAN
Jakarta

Nuclear Research area
Pasar Jumat

Uranium exploration
Kalan, West Kalimantan

# RESEARCH AREAS

EPR

Nuclear Research Area
Serpong

Nuclear Research area
Bandung

Nuclear Research area
Yogyakarta

# Objective of Assesment

- The study is aimed to obtain
  - a conceptual design of nuclear cogeneration system coupled with a coal liquefaction unit
  - technical specification of materials and components for cogeneration system.
  - The technical specification which includes function, capacity, dimension and operational parameter, and others is assessed based on operational condition, mass balance and heat balance, and production capacity, as well.

# SASOL in South Africa

**Indirect Coal liquefaction is proven technology**

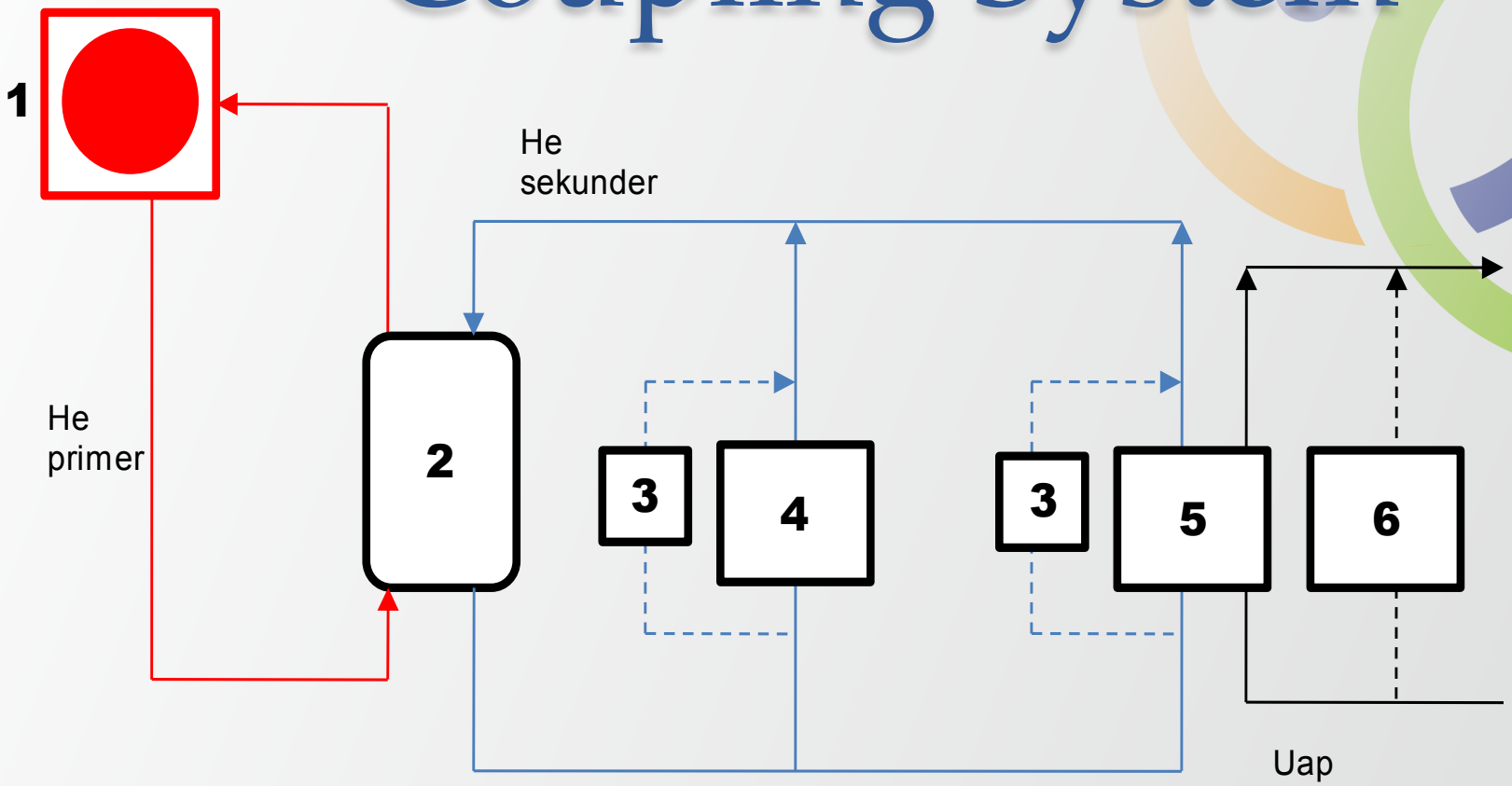
- South Africa's SASOL Co. developed a commercial coal liquids industry (fuel plus chemicals)
- The plant produces about 150,000 barrels daily at its second plant

# Two Basic Approaches of Coal Liquefaction

1. Direct Liquefaction (450 – 500C):
   - Coal + H2 + catalyst → hydrocarbons
2. Indirect Liquefaction (~800C):
   - Gassification followed by reacting carbon monoxide and hydrogen together (FT synthesis)

$$nCO + (2n+1)H_2 + \text{catalyst} \rightarrow \text{hydrocarbons}$$

# Coupling System




1) HTGR, 2) heat exchanger He-He, 3) emergency coolant, 4) tubin-generator, 5) heat echanger He-Steam, 6) *furnace*

# He-He IHX

- He-He heat exchanger is a heat exchanger between the primary helium to the secondary helium .
- Primary Helium coolant temperature is high , while the secondary is a helium carrier medium heat for power generation and gasification processes .
- This heat exchanger  is also serve as a mean to keep helium pure  from contaminants of gasification products and others contaminants

# Comparison of 2 types He-He HX

| | U-Tube countercurrent compact | | | | Helical Type design | | | |
|---|---|---|---|---|---|---|---|---|
| | PNP | | KVK | | PNP | | KVK | |
| | prim | sec | prim | sec | prim | sec | prim | sec |
| Power MW | 125 | | 10 | | | | | |
| Flow kg/s | 36,9 | 35,6 | 3,0 | 2,9 | 36,9 | 35,6 | 2,95 | 2,85 |
| Tin °C | 950 | 220 | 950 | 220 | 950 | 220 | 950 | 220 |
| Tout°C | 293 | 900 | 293 | 900 | 293 | 900 | 293 | 900 |
| Number of Tubes | 1900 | | 180 | | 1444 | | 117 | |
| Length of Tube m | 32,7 | | 32,7 | | 17,5 | | 17,5 | |

- KVK (Komponenten-Versuchs-Kreislau *Component Experimental Loop*, INTERATOM)
- - PNP (*Prototype Plant Nuclear Process Heat*)

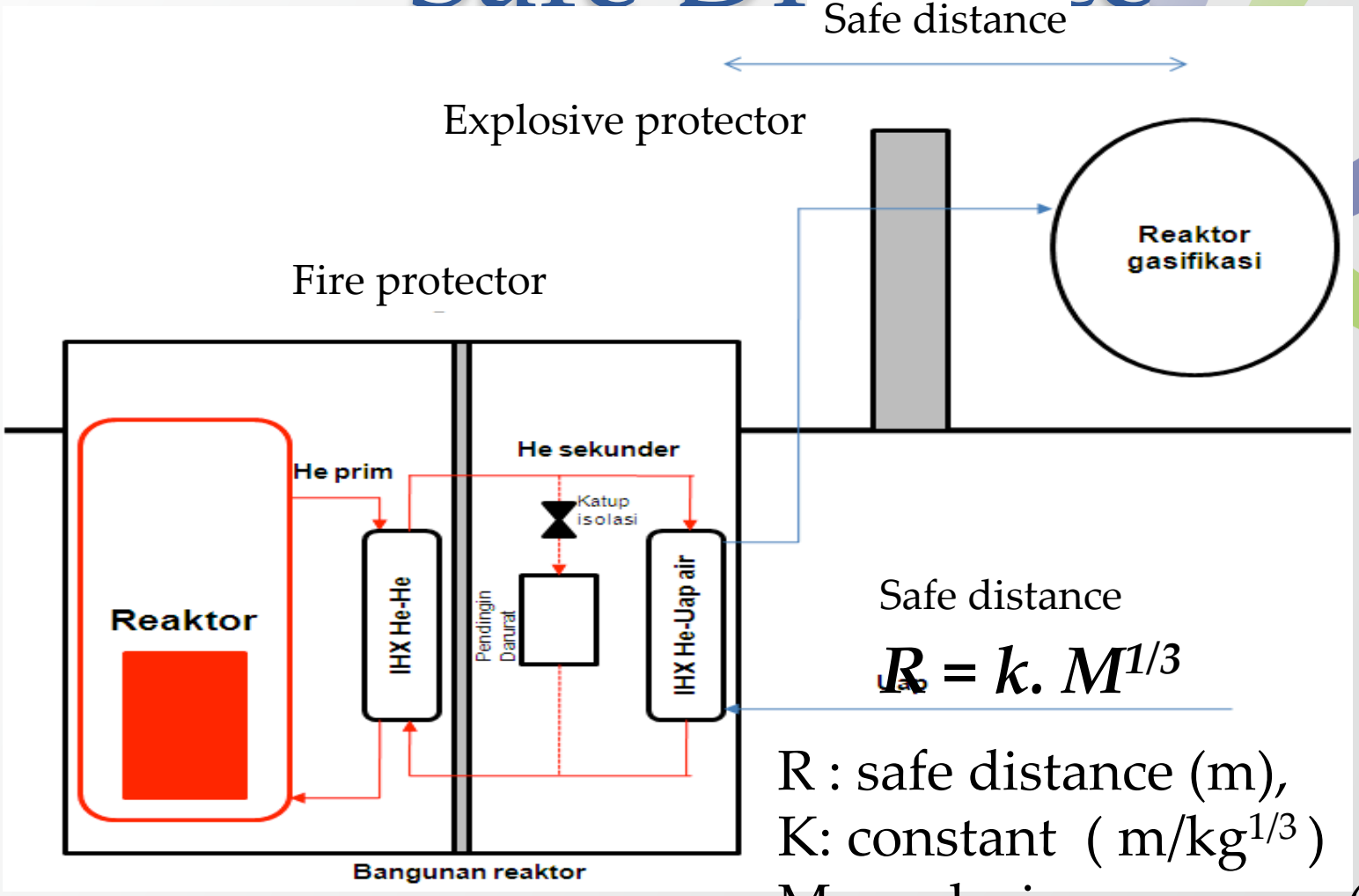
# Emergency cooling system

- Emergency Cooling serves as the coolant / heat sink for secondary helium gas in the event of a problem on one of the generation plant or gasification plant.
- Emergency cooling consists of several coolers that will cool the heat of helium gas that will be used by generation plant or gasification plant .
- This system ensures that the cooling can still function whenever problem occurs in either system.
- Emergency Cooling is equipped with isolation valves which serve to cut the flow of He secondary coolant to emergency cooling.

# He-Steam Heat Exchanger

- He-Steam heat exchanger  is a substitute for furnaces used in conventional gasification process.
- At NPP HTGR cogeneration system with gasification plant, the steam that will be used in the gasification plant is circulated first through  the heat exchanger to accept sensible heat from the secondary helium.
- The secondary helium is sent back to the He-He heat exchanger after mixed with the secondary helium from generation plant

# Safe Distance




Safe distance

$$R = k.\ M^{1/3}$$

R : safe distance (m),

K: constant ( $m/kg^{1/3}$ )

M: explosive gas mass (kg)

# Components

- Intermediate Heat Exchanger (IHX), recuperator, pre-cooler, inter-cooler, crusher, hopper feeder, vibrating screen, belt conveyor, gasifier, cyclone, adsorber, shift converter, kondensor, reaktor Fischer Tropsch, decanter,  and destilation tower

# Specification

- Specification of component for gasification is obtained based on mass balance and heat balance in operation condition
- *Indirect Coal Liquefaction* process based on SASOL technology
- Helium:
  - temperature 950 °C,
  - Pressure 50 MPa,
  - Flowrate 115 kg/s (414.000 kg/h),

# Supply Specification

Coal

- Size 5 mm at 30 °C and pressure 1 atm
- Flowrate 25.000 kg/h.

Steam

- temperature 1.400 °C
- *flowrate* 20.000 kg/jam, .

Water

- Flowrate from utilitiy unit 20.000 kg/h
- pumped to attain pressure of 29,58 atm
- Flows to *waste heat boiler* to atain temperature of 230 °C.
- Mixture of water and saturated steam flows to separator:
  - Water is reuse as supply water
  - *Steam is* flowedin heat exchenger with helium from the reactor (950 °C) to be 755 °C.
  - *Steam* is then reheated *furnace* using *fuel gas* (by-product of the process) and air to attain temperature of 1.400 °C before supplied to gasification reactor

# Specification

Specification has been obtained on:

A. Supply material for gasification process
B. Auxiliary material for gasification process
C. Components specification

# THANK FOR
# YOUR KIND ATTENTION