

# Nuclear Power & Singapore



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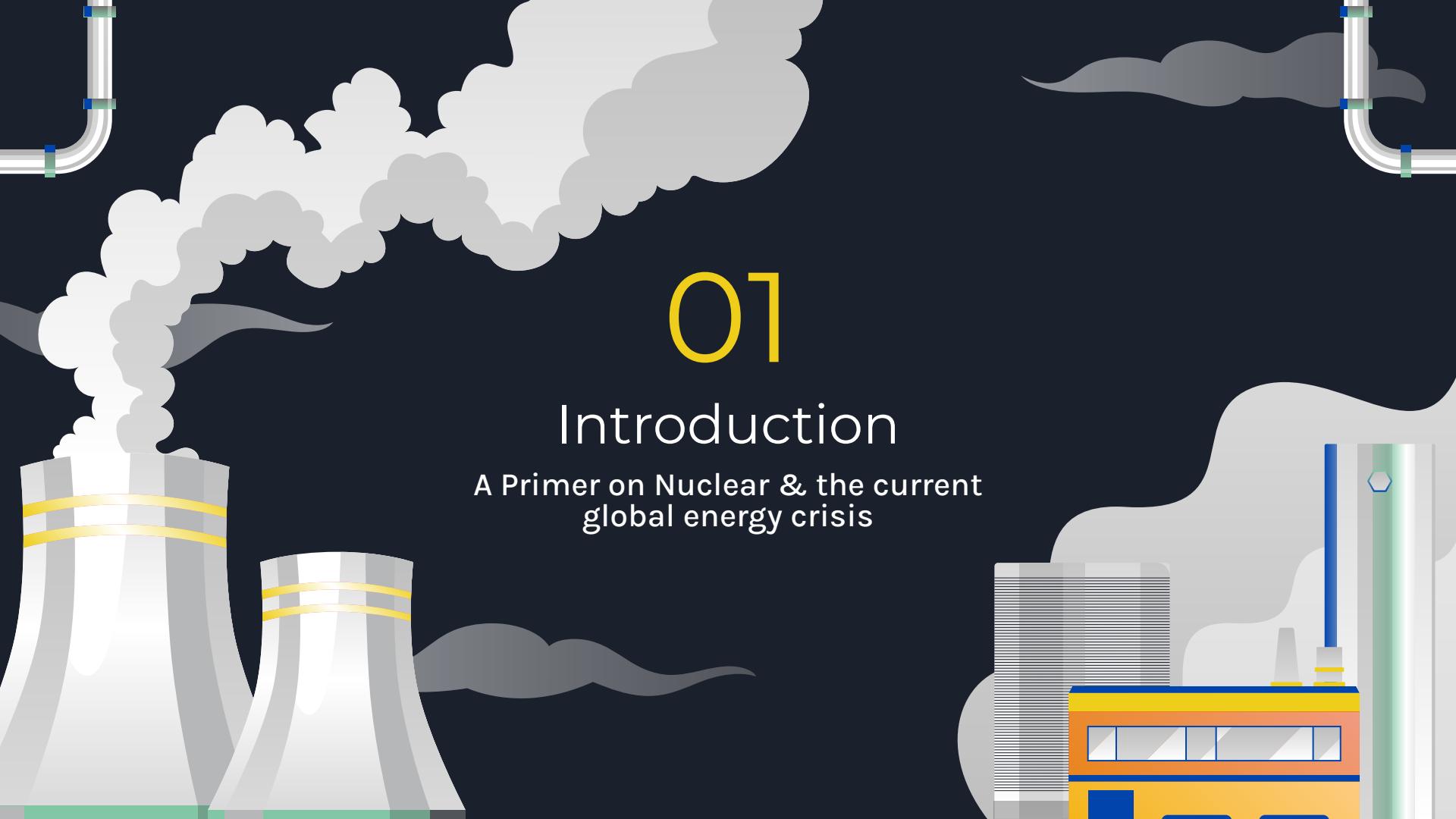
Advantages

03

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04

Feasibility

The background of the slide features stylized illustrations of industrial structures. On the left, two grey cooling towers with yellow horizontal bands emit large plumes of white and grey smoke against a dark navy blue background. On the right, a similar structure is partially visible, along with a vertical pipe and a green cylindrical tank.

# 01

## Introduction

A Primer on Nuclear & the current  
global energy crisis

# Pretext



YouTube | Kazuhiro Maeyama  
China: world's third largest river dries up in drought  
**Aug 2015**

China: world's third largest river dries up in drought

**Aug 2015**



**Aug 2022**

The  
Guardian



# Pretext

THE STRAITS TIMES

SINGAPORE

## Singapore explores tapping nuclear energy by 2050

### Written reply to PQ on Nuclear Energy

#### Question

**Assoc Prof James Jerome Lim:** To ask the Minister for Trade and Industry (a) whether the decision to embark on nuclear power may be precluded by the much more rapid decline of costs per megawatt hour for renewables relative to the much slower decline in nuclear power; and (b) if so, whether resources directed towards nuclear plant construction may be better deployed towards renewables.

#### Written Answer by Second Minister for Trade and Industry Tan See Leng

1. Singapore has been exploring various solutions to decarbonise the grid as part of our commitment to achieving a low-carbon energy future under the Singapore Green Plan 2030, and our Long-term Low Emissions Development Strategy.

2. Singapore has limited potential to deploy renewable energy. At present, solar energy remains the most viable renewable energy option for Singapore. However, we have limited land for the large-scale deployment of solar panels. In addition, the presence of high cloud cover across Singapore and urban shading pose challenges such as intermittency.

3. Given these limitations, we are looking into importing energy to Singapore. We are also looking at developing the infrastructure and policies for low carbon alternatives like hydrogen, which can be used to transport renewable energy to Singapore. However, low carbon technologies such as hydrogen are currently nascent, and uncertainties remain on whether and when they can become cost-viable for large-scale deployment. We are also monitoring the developments in nuclear energy, as well as building capabilities to better understand and assess their safety, security and environmental implications.

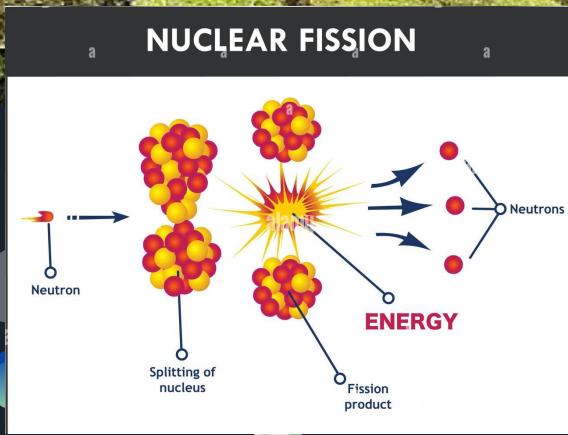
4. It is against this context that the Energy 2050 Committee developed the three pathways that Singapore could take to achieve net-zero by 2050, one of which included the option of nuclear energy. Our future energy mix will depend on various factors, including the advances in various low-carbon technologies, as well as collaboration and trading of low-carbon energy across borders. Any decision to deploy new energy technologies will need to weigh carefully their safety, reliability, affordability and environmental sustainability. In the meantime, we will continue to enhance energy efficiency across all sectors and encourage consumers to play their part to conserve energy, to reduce our overall demand and reliance on energy.

# Research Question

How feasible is adopting nuclear energy to meet Singapore's energy needs and advance our goal of net-zero by 2050?

P	E	S	T	L	E
Political	Economical	Social	Technological	Legal	Environmental

# Nuclear: a primer



Clean energy; does not generate carbon emissions in power generation



Non-renewable source of energy



# 02

## Advantages

- Strategic Need
- Socio-economic
- Energy generation potential

# Strategic importance for “Energy Independence”



Russia's stated aim is to capture and control Ukraine's eastern region of Donbas

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Insights on building a secure and sustainable energy future Learn more Life Is On | Schneider Electric

**ENERGY**

## Russia has cut off gas supplies to Europe indefinitely. Here's what you need to know

PUBLISHED TUE, SEP 6 2022 9:49 AM EDT | UPDATED TUE, SEP 6 2022 8:30 PM EDT

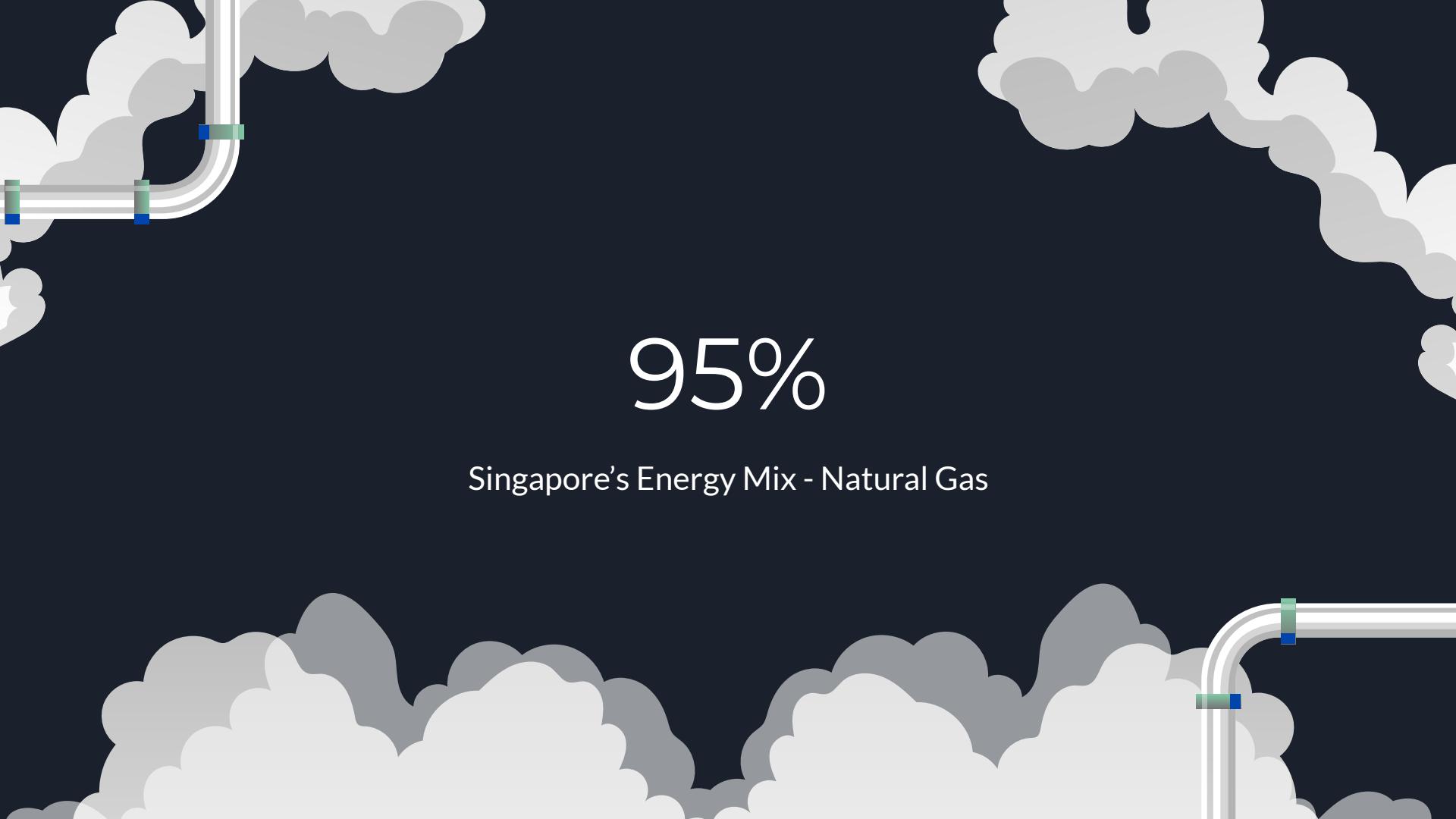
 **Sam Meredith**  
@SMEREDITH19

WATCH LIVE

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**KEY POINTS**

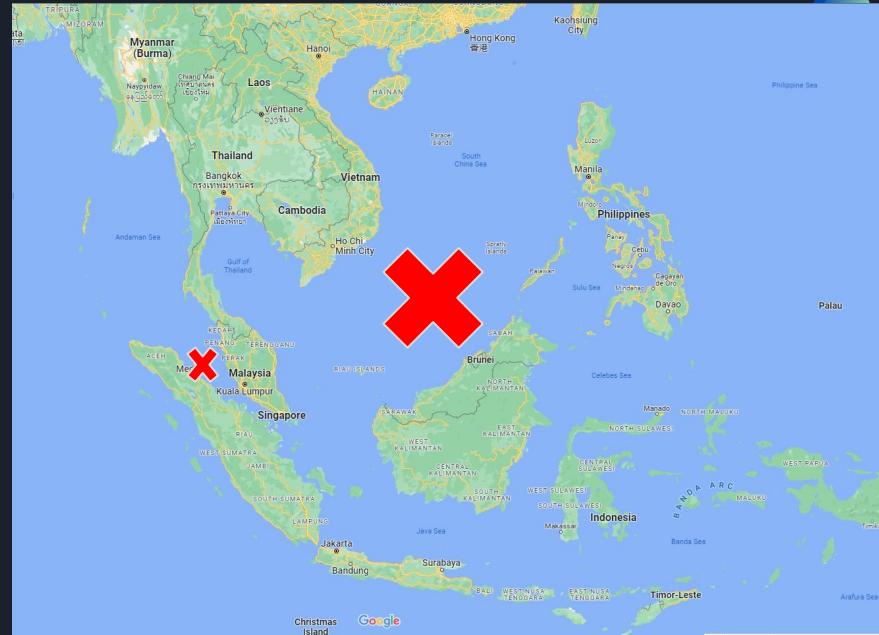
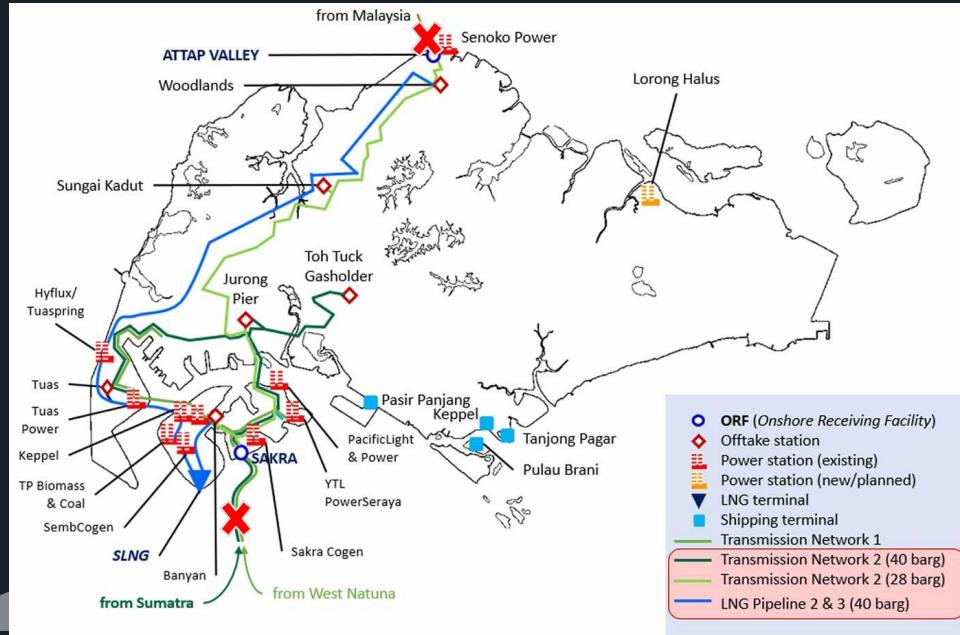
- Russia claims punitive economic sanctions imposed by the West are responsible for the indefinite halt to gas supplies via Europe's main pipeline.
- It represents the clearest indication yet that the Kremlin is seeking to force Europe to lift the economic measures in order for Moscow to turn the taps back on ahead of winter.
- “This latest move has significantly increased the risk that Europe may not get further gas flows through Nord Stream 1 for the whole winter,” analysts at energy consultancy Rystad Energy said in a research note.



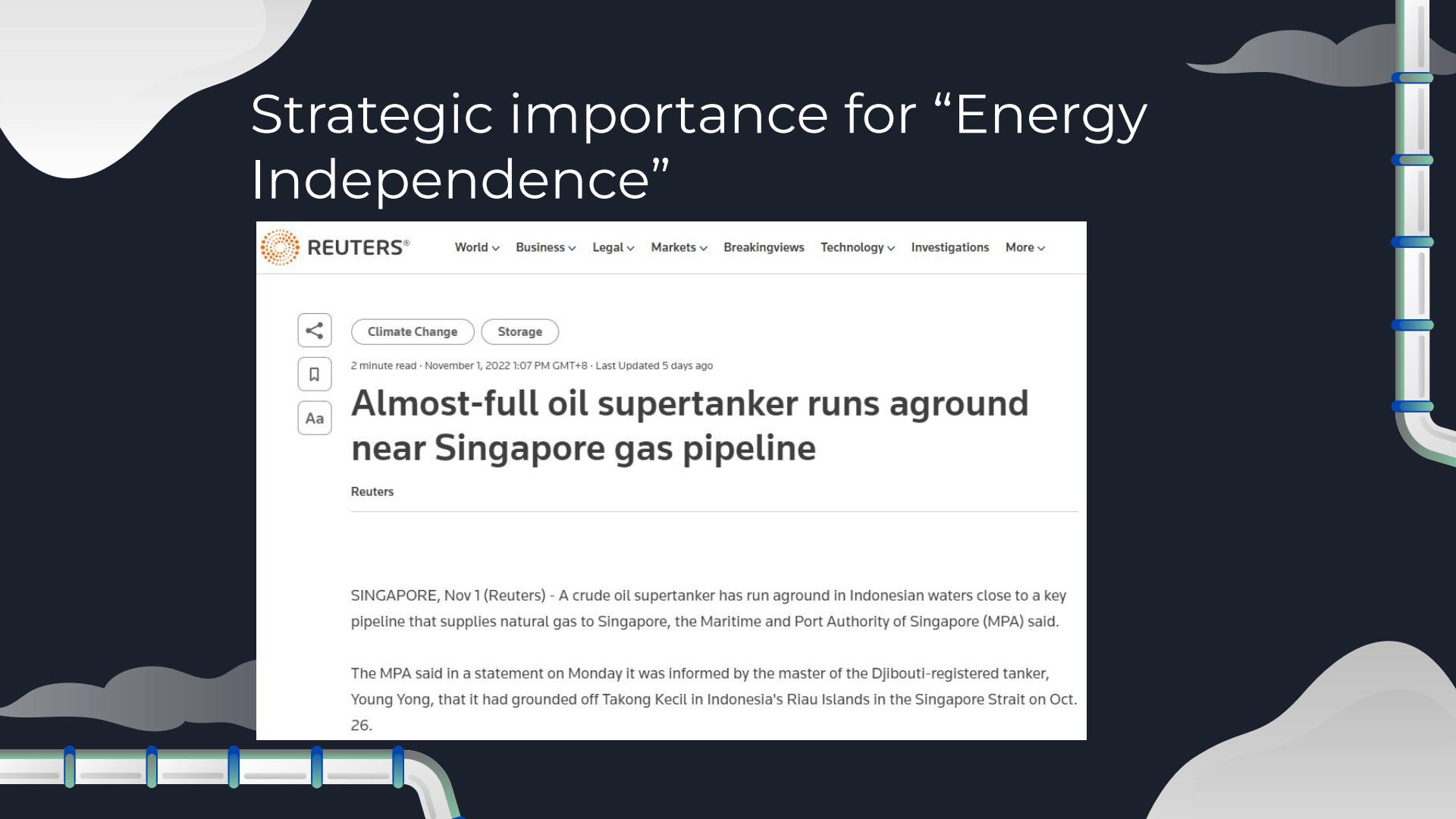
95%

Singapore's Energy Mix - Natural Gas

# Strategic importance for “Energy Independence”



# Strategic importance for “Energy Independence”



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 Climate Change 

2 minute read · November 1, 2022 1:07 PM GMT+8 · Last Updated 5 days ago

## Almost-full oil supertanker runs aground near Singapore gas pipeline

Reuters

SINGAPORE, Nov 1 (Reuters) - A crude oil supertanker has run aground in Indonesian waters close to a key pipeline that supplies natural gas to Singapore, the Maritime and Port Authority of Singapore (MPA) said.

The MPA said in a statement on Monday it was informed by the master of the Djibouti-registered tanker, Young Yong, that it had grounded off Takong Kecil in Indonesia's Riau Islands in the Singapore Strait on Oct. 26.

# Socio-Economic Issues & Benefits

## European Union Natural Gas Import Price

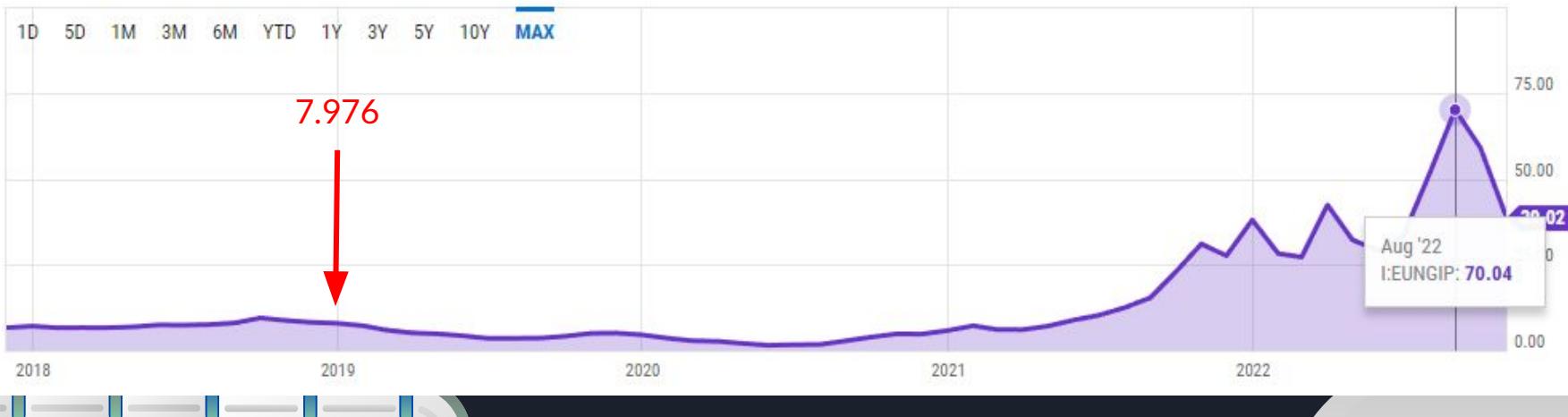
39.02 USD/MMBtu for Oct 2022

Overview

Interactive Chart

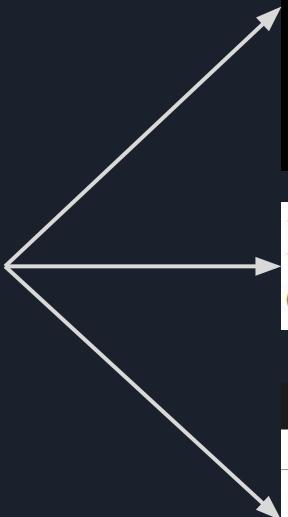
Level Chart

VIEW FULL CHART



# Socio-Economic Issues & Benefits

Soaring energy prices



nytimes.com/2022/09/19/business/europe-energy-crisis-factories.html

## *'Crippling' Energy Bills Force Europe's Factories to Go Dark*

Manufacturers are furloughing workers and shutting down lines because they can't pay the gas and electric charges.

Higher gas prices deepen Europe's fertiliser crunch, threaten food crisis

Bloomberg

• Live Now Markets **Economics** Industries Technology Politics Wealth Pursuits Opinion Businessweek Equality Green

Asia Edition ▾

**Economics**  
Inflation & Prices

## German Inflation Unexpectedly Soars, Heaping Pressure on ECB

- Consumer prices jumped 11.6% in October; median est. 10.9%
- Data also came in above analyst estimates in Italy and France

# Socio-Economic Issues & Benefits

 **REUTERS®** World ▾ Business ▾ Legal ▾ Markets ▾ Breakingviews Technology ▾ Investigations More ▾

 Nuclear  Governance 

 4 minute read · September 6, 2022 4:09 AM GMT+6 · Last Updated 2 months ago

 **Germany keeps two nuclear reactors on standby to weather gas crisis**

By Vera Eckert and Sarah Marsh



A general view shows the nuclear power plant Isar 2 by the river Isar in Eschenbach near Landshut, Germany, August 17, 2022.  
REUTERS/Christian Mang

# Socio-Economic Benefits

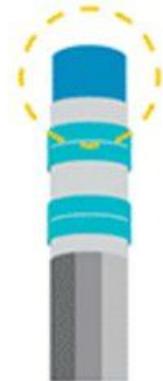


# Energy generation potential



# What about nuclear?

*1 Uranium pellet  
(eraser sized)*



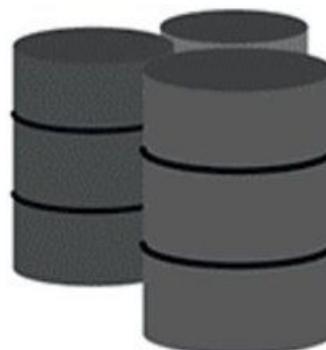
=

*1 ton  
of coal*



=

*3 barrels  
of oil*



=

*17,000 ft<sup>3</sup> of  
natural gas*



# What about nuclear?



# 03

## Challenges of nuclear energy



# What are some concerns?



Psychological resistance



Competing land space needs  
and uses in Singapore



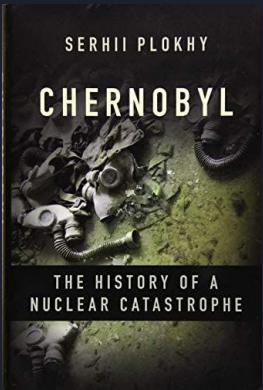
Type of nuclear reactors

Safety of nuclear energy





# Psychological resistance to nuclear energy



Rejection of Nuclear energy

# Death rate from accidents and air pollution

Measured as deaths per terawatt-hour of electricity production.  
1 terawatt-hour is the annual electricity consumption of 150,000 people in the EU.

**24.6** deaths

1230-times higher than solar

**18.4** deaths

613-times higher than nuclear energy

**2.8** deaths

**Coal**

36% of global electricity

**Oil**

3% of global electricity

**4.6** deaths

**Natural Gas**  
22% of global electricity

**Biomass**  
2% of global electricity

**1.3** deaths

171,000 deaths from Banqian Dam failure in 1975, China

**0.04** deaths

**Hydropower**  
12% of global electricity

**0.03** deaths

Includes deaths from Chernobyl and Fukushima disasters

**Wind**  
7% of global electricity

**0.02** deaths

**Nuclear energy**  
10% of global electricity

**Solar**

4% of global electricity

Myth  
Tir



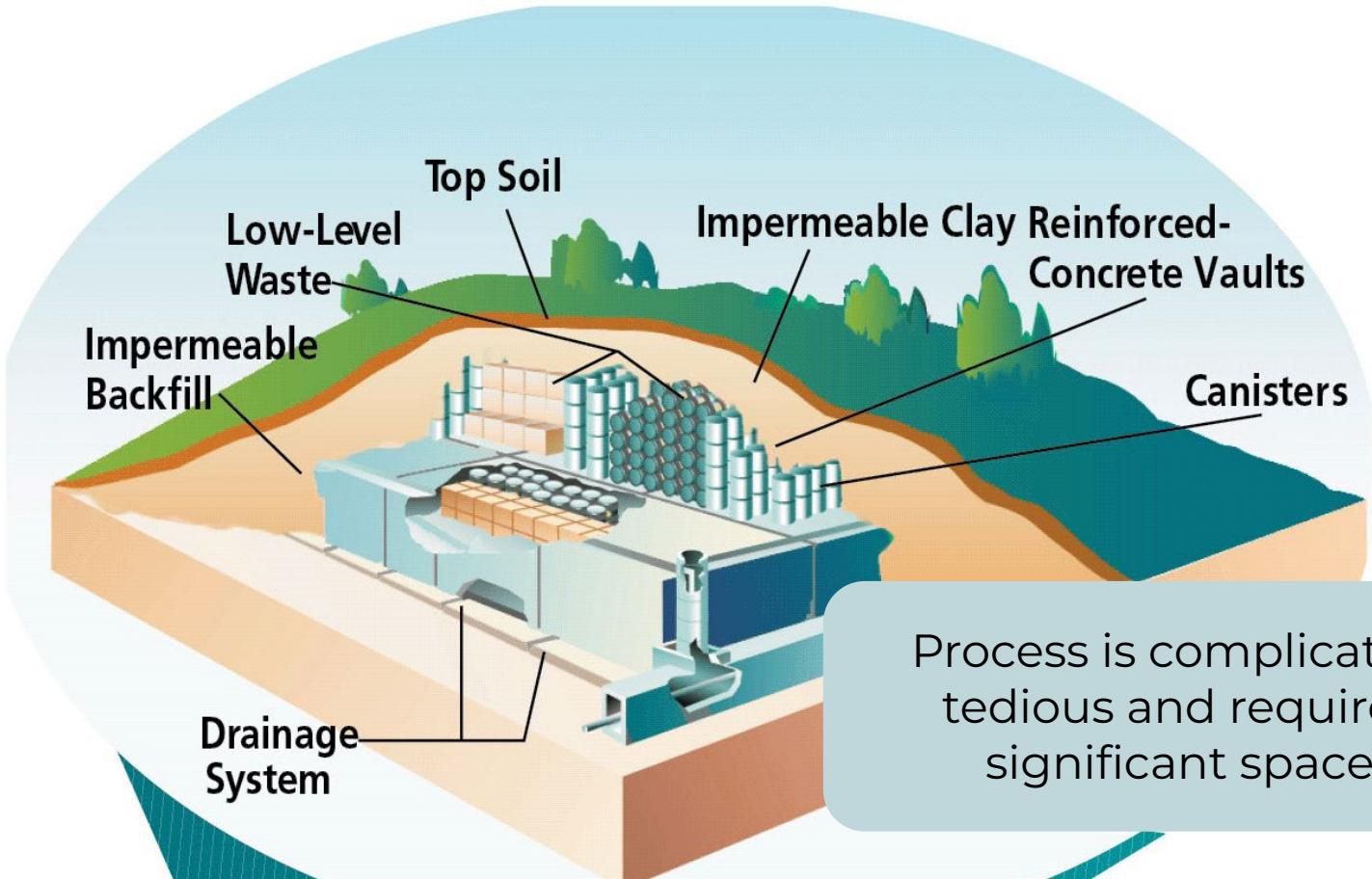


Where can we place  
nuclear power plants?

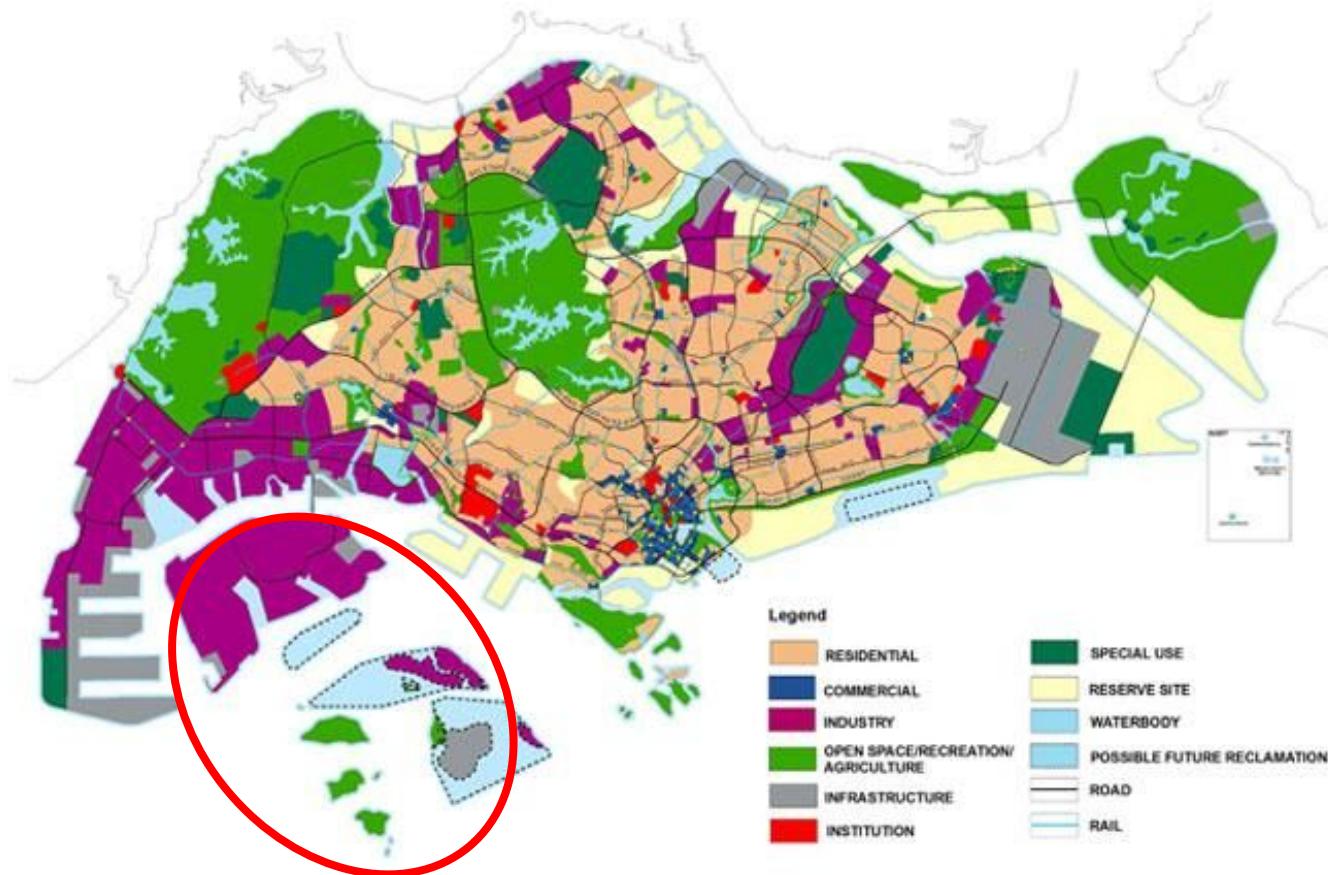


Where can we  
store nuclear  
waste?

# Low-Level Waste Disposal



# So... how to Nuclear?



Map of Land use beyond 2030 (Ministry of National Development)

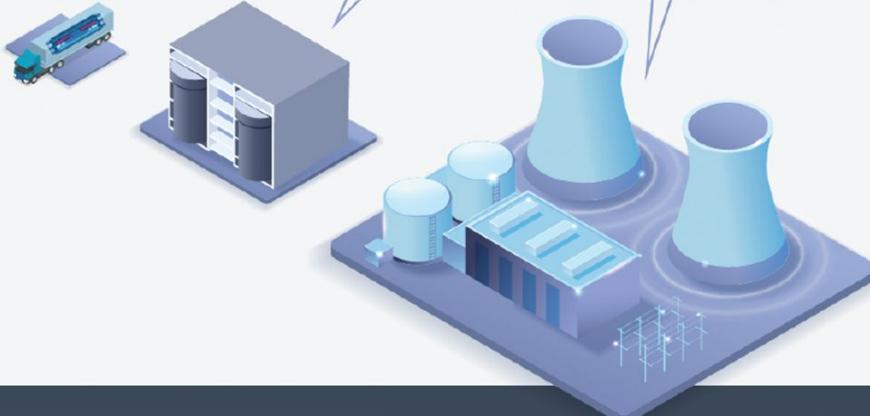
# So... how to Nuclear?

## Small Modular Reactors (SMR)

Microreactor  
1 MW - 20 MW

Small Modular Reactor  
20 MW - 300 MW

Large-Scale Reactor  
300 MW - 1,000+ MW



### NUSCALE POWER MODULE™

NATURAL CIRCULATION OF REACTOR COOLANT FLOW

#### CONDUCTION

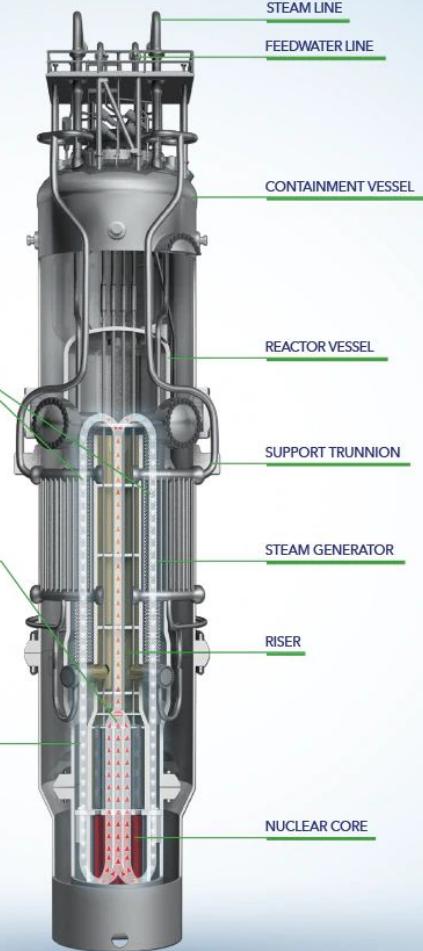
Heat is transferred from the primary coolant through the walls of the tubes in the steam generator, heating the water (secondary coolant) inside them to turn it to steam.

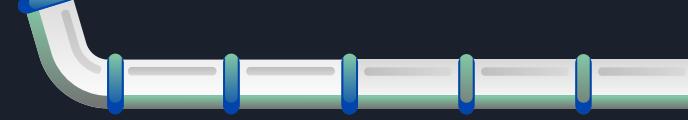
#### CONVECTION

Energy from nuclear reaction heats the primary reactor coolant causing it to rise by convection and natural buoyancy through the riser, much like a chimney effect.

#### GRAVITY

Colder (denser) primary coolant "falls" to bottom of reactor pressure vessel, cycle continues.



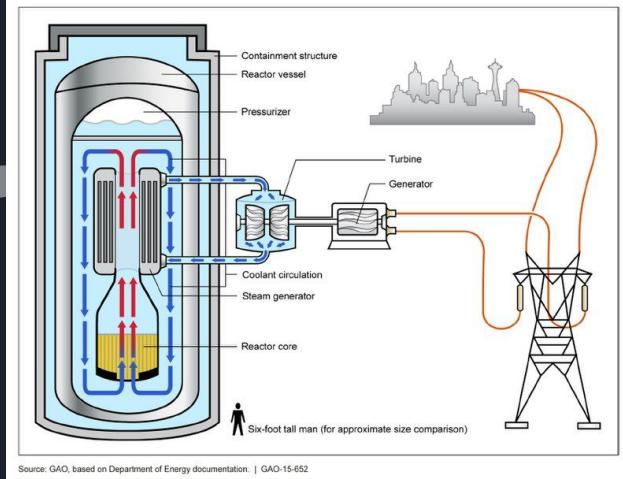
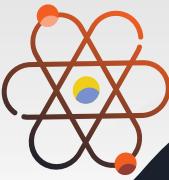


# 04

# Feasibility of Nuclear

To nuclear... or not to nuclear... remains the question





The infancy of SMR  
technology

Safety of using nuclear  
energy



# Should we rely on new technology?



**Akademik Lomonosov**  
**Floating Nuclear**  
**Co-Generation Plant**

# Should we rely on new technology?

Innovative Advancements to Reactor Safety

for DC power\*

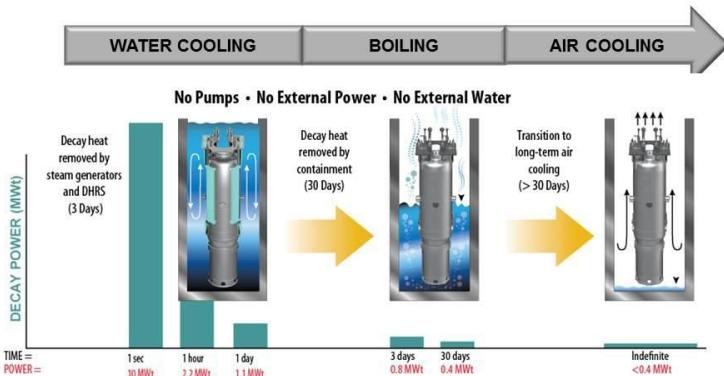
AIR COOLING

**WORK IN  
PROGRESS**



# There is potential

## Innovative Advancements to Reactor Safety *Nuclear fuel cooled indefinitely without AC or DC power\**



## WHO'S INVESTING IN SMRS?

Electricite de France, China National Nuclear, Japan's Toshiba and Russia's Rosatom are pushing SMR designs, as is NuScale. Gates and Buffett have teamed up to build and test a reactor at an abandoned coal plant in Wyoming.

Rolls-Royce Holdings raised £455 million (US\$608 million) to fund the development of SMRs, with almost half of the financing coming from the UK government. The Canadian and US governments have also offered hundreds of millions of dollars in subsidies to kick-start the SMR industry.

\* 30 days is a minimum based on very conservative estimates.

\*Alternate 1E power system design eliminates the need for 1E qualified batteries to perform ESFAS protective functions - Patent Pending

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# There is potential

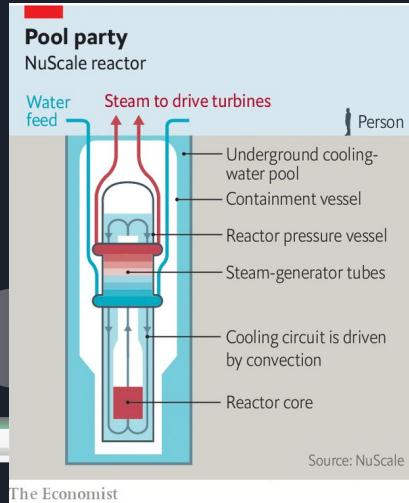


2 GWp (2000 MWp) of solar energy by 2030



350,000 households

300 MWp/SMR

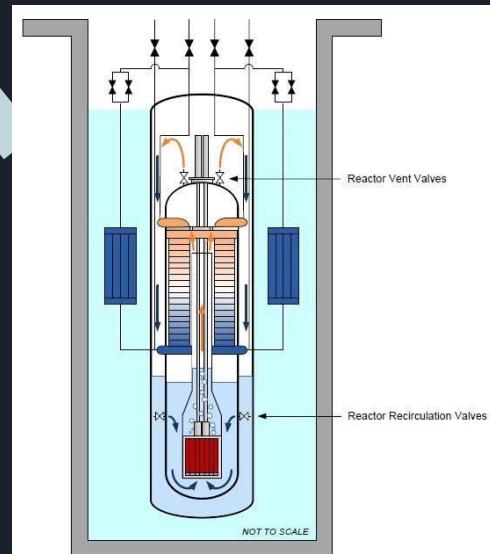


52,500 households

# How safe can it be?



Floating Nuclear Power Plants (FNPP)  
using Light Water Reactor (LWR)  
Technology

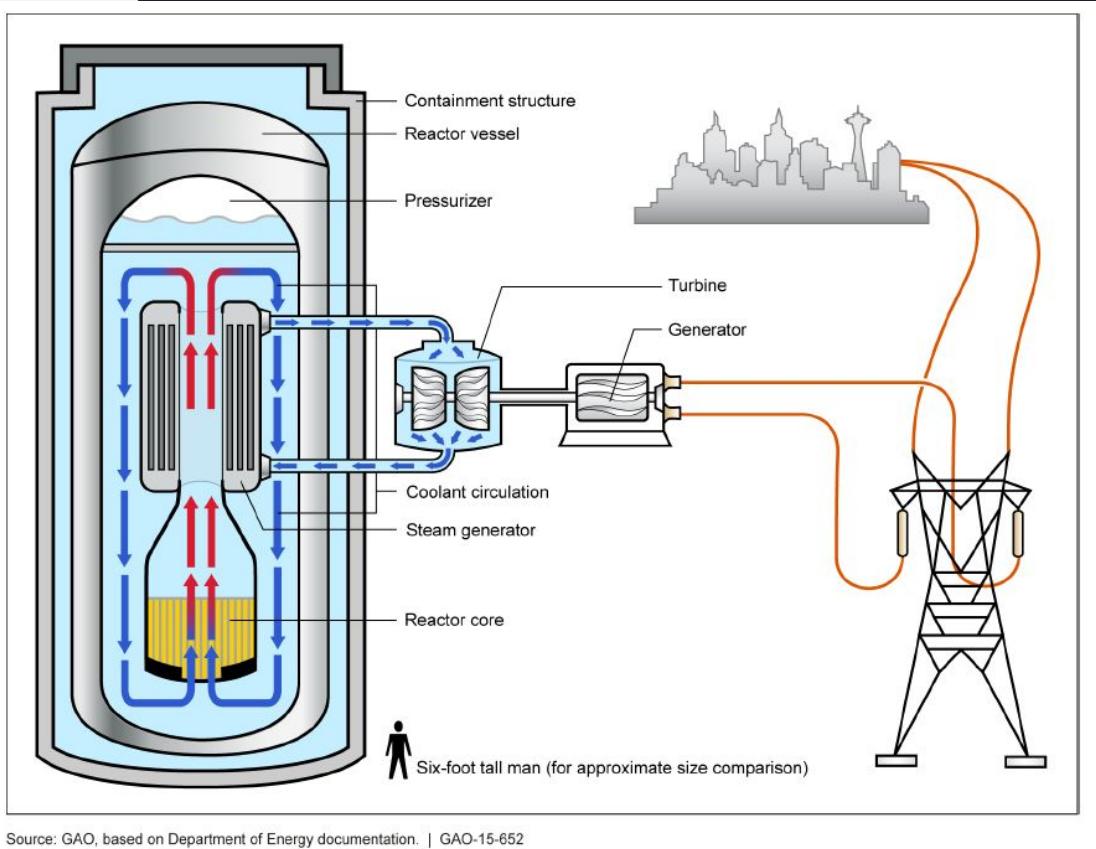


# How safe can it be?



Mobile systems on water offers greater flexibility

# How safe can it be?



Source: GAO, based on Department of Energy documentation. | GAO-15-652

Smart innovative technology (automatic shut-down)

Higher levels of passive safety systems

# Safety

 **IAEA**  
International Atomic Energy Agency

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/ Ukraine's Zaporizhzhya Nuclear Power Plant lost off-site power again, diesel generators providing back-up electricity

## Ukraine's Zaporizhzhya Nuclear Power Plant lost off-site power again, diesel generators providing back-up electricity

03 Nov 2022  
180/2022  
Vienna, Austria



# Safety



# Financing via SINGA

The screenshot displays the Singapore Statutes Online website. The top navigation bar includes links for Home, Browse, What's New, Help, About Us, My Collections, and Search. The right side of the header features a "FAQs | Feedback" link and font size adjustment buttons (A-, A+). The main content area shows the "Significant Infrastructure Government Loan Act 2021". The sidebar on the left provides a table of contents for the act, listing sections such as Part 1 PRELIMINARY, Part 2 AUTHORITY AND APPLICATION OF LOAN, and Part 3 BORROWING. The main content area includes a title banner for "SIGNIFICANT INFRASTRUCTURE GOVERNMENT LOAN ACT 2021", a note about the 2020 REVISED EDITION, and a summary of the act's purpose. The document is dated [3 August 2021]. The page also includes sections for Short title, Interpretation, and Purpose of Act.

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Timeline Subsidiary Legislation  Amendment Annotation

Actions

**Significant Infrastructure Government Loan Act 2021**

**Status:** Current version as at 07 Nov 2022 ⓘ

**Significant Infrastructure Government Loan...**

**Table of Contents**

**Significant Infrastructure Government Loan Act 2021**

**Long Title**

**Part 1 PRELIMINARY**

- 1 Short title
- 2 Interpretation
- 3 Purpose of Act

**Part 2 AUTHORITY AND APPLICATION OF LOAN**

- 4 Power to raise loan
- 5 Borrowing limit
- 6 Issuing securities for borrowing

Reset Get Provisions Whole Document

**SIGNIFICANT INFRASTRUCTURE  
GOVERNMENT LOAN ACT 2021**

2020 REVISED EDITION

This revised edition incorporates all amendments up to and including 1 December 2021 and comes into operation on 31 December 2021

An Act to authorise loans to be raised by the Government for the purposes of the Development Fund in relation to nationally significant infrastructure.

[3 August 2021]

**PART 1**

**PRELIMINARY**

**Short title**

1. This Act is the Significant Infrastructure Government Loan Act 2021.

**Interpretation**

2. In this Act, unless the context otherwise requires —

# Financing via SINGA

“nationally significant infrastructure” means any structure or building in Singapore (whether above or below ground or water) that –

(b) is or is intended primarily for any of the following purposes or a combination of any of the following purposes:

(v) the generation, transmission or distribution of electricity, gas or other energy or power;

## Purpose of Act

3. The purpose of this Act is to enable financing by borrowing to meet the Government’s commitment to Singapore’s future by investing in nationally significant infrastructure and their related facilities in which initial or further investment is vital to supporting or is likely to materially improve national productivity or Singapore’s economic, environmental or social sustainability.

The background of the slide features a stylized industrial scene. On the left, there are two large grey cooling towers with yellow horizontal stripes, emitting thick white smoke. Below them is a building with a yellow roof and blue windows. A complex network of white pipes with blue and green valve-like components runs across the top and bottom of the frame. Large, billowing white clouds are scattered across a dark grey sky.

Let's wrap up

# Advantages



## Strategic



## Socio-econ



## Environmental

# Challenges



## Psychological resistance

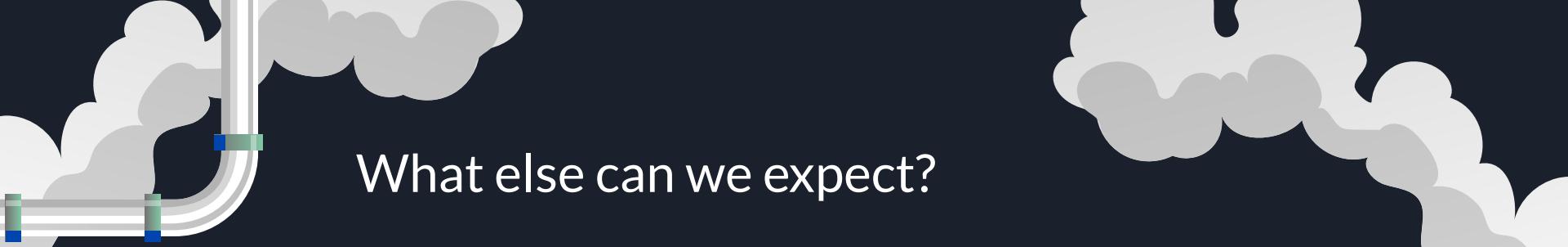
# A fusion-heavy grid will require policy changes. It is therefore worth starting conversations today, as these changes could take years to implement.

**Critical uncertainties:** The patterns of technology advancement for low-carbon energy technologies, such as low-carbon hydrogen and new geothermal and nuclear technologies, are not clear as they hinge on R&D efforts bearing fruit, the scale of deployment by major countries, and the global price on carbon. The pace of digital technology advancements in the power sector is uncertain as it is contingent upon the affordability of enabling infrastructure such as advanced computing processors, communications infrastructure, sensors, and power controllers. The impetus for collective action on international power and carbon trading is also unknown, given that national interests and priorities may not be fully aligned with the push for decarbonisation.





Thank you  
Yeehaw Nuclear energy!



# What else can we expect?

Deuterium



Tritium

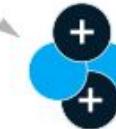


Fusion reaction



Neutron

Energy out



Helium

# USS Ronald Reagan Docking in Singapore

THE STRAITS TIMES

SINGAPORE

LOG IN

US aircraft carrier docks in Singapore  
for first time since 2019



The USS Ronald Reagan is here for a routine port visit for a few days. ST PHOTO: ALPHONSUS CHERN



## WELCOME

USS Ronald Reagan (CVN 76) is the ninth Nimitz-class nuclear-powered aircraft carrier and is named in honor of the 40th president of the United States.

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Further readings (or “watchings”)

