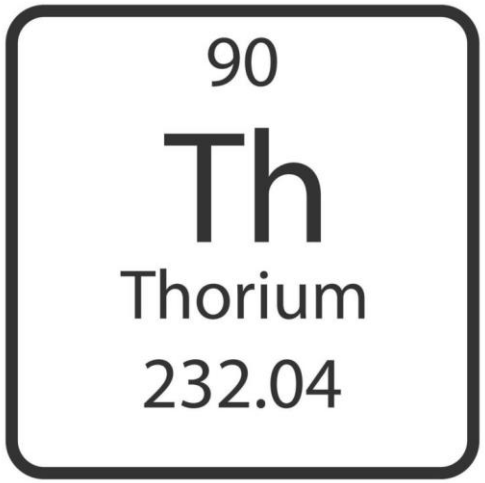
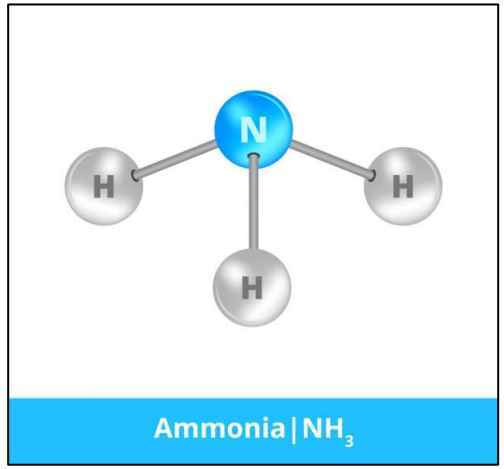
Clean Ammonia powered by - Thorium

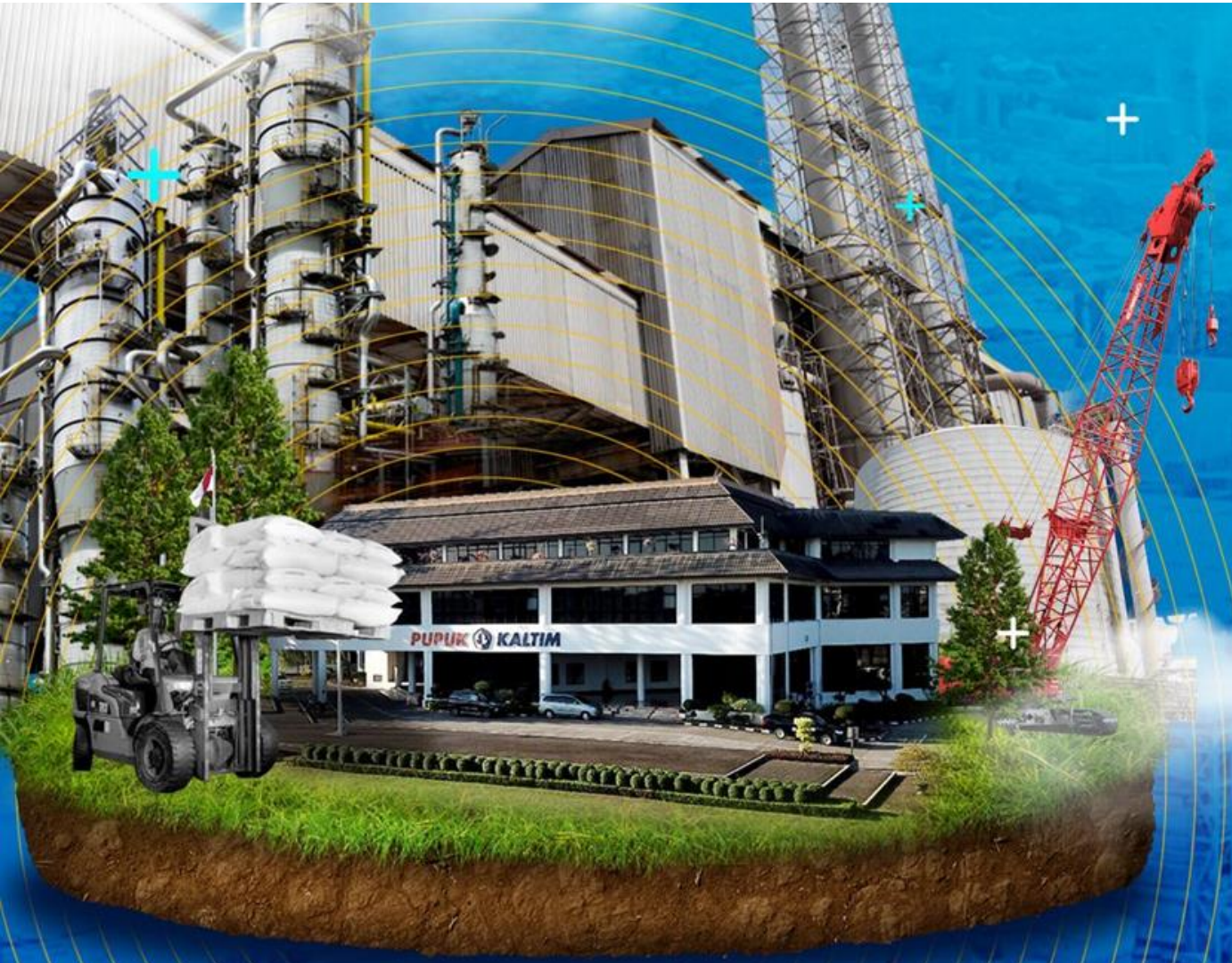




Content

1. Pupuk Kaltim Company Profile
2. Copenhagen Company Profile
3. Project Description
4. Clean Ammonia
5. Thorium Molten Salt Reactor

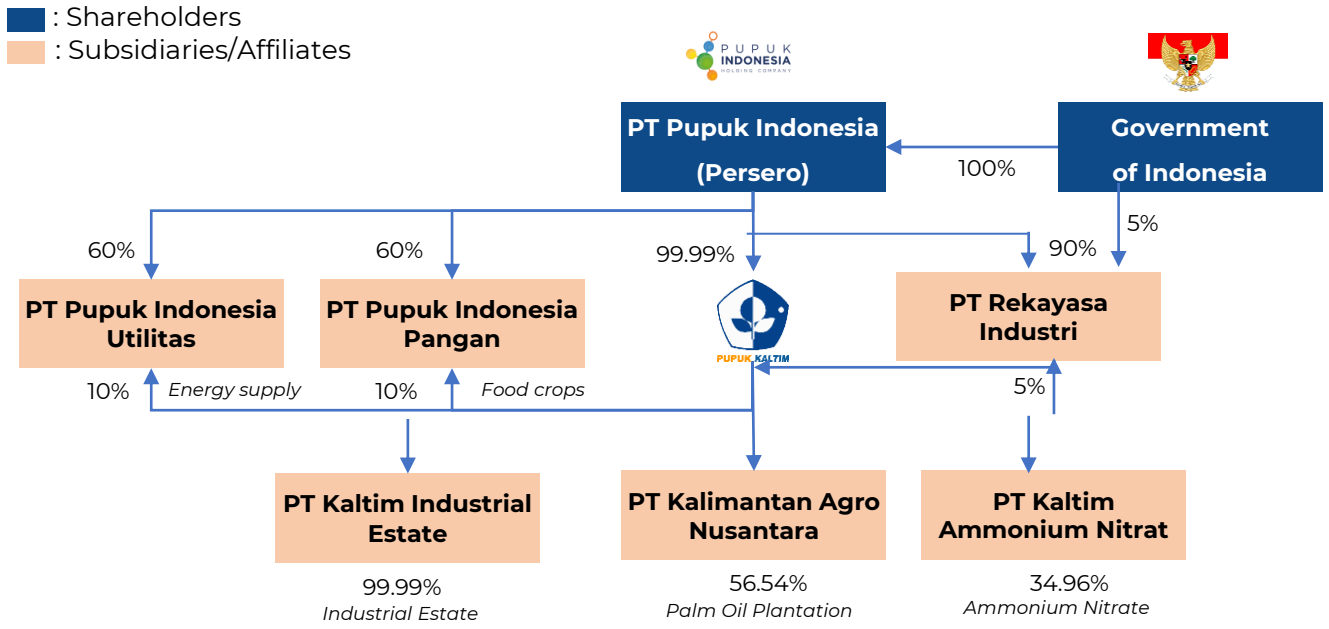
Pupuk Kaltim Company Profile



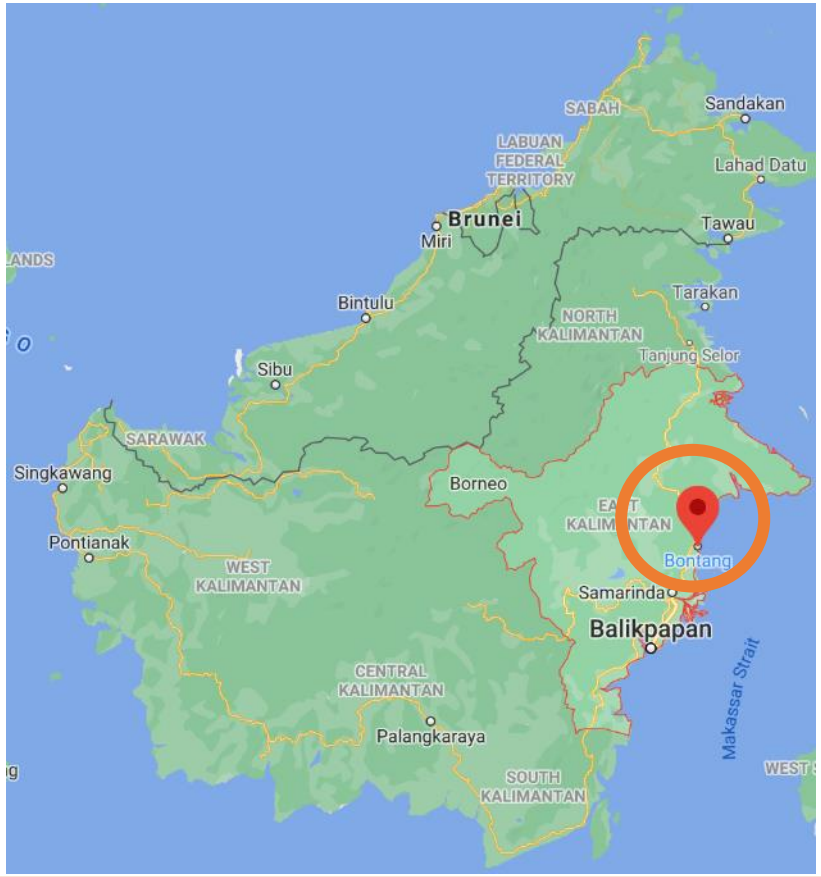
PT PUPUK KALTIM
Company Profile

PKT AT A GLANCE

OWNERSHIP



PKT is an Indonesian state-owned company



We are located in Bontang, East Borneo

PKT AT A GLANCE

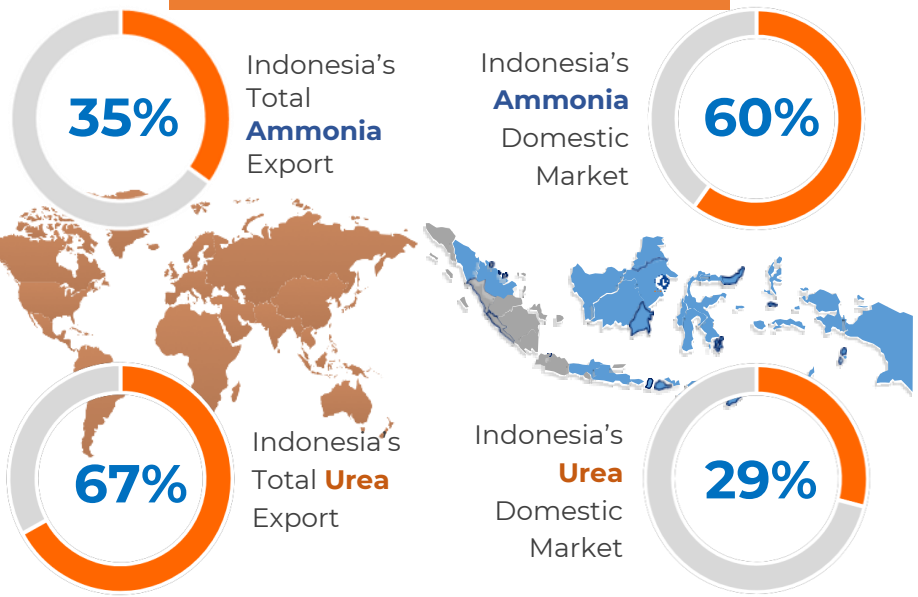
Vision:

Become a world-class company that provides innovative and competitive solutions in agribusiness and chemical for a sustainable future.

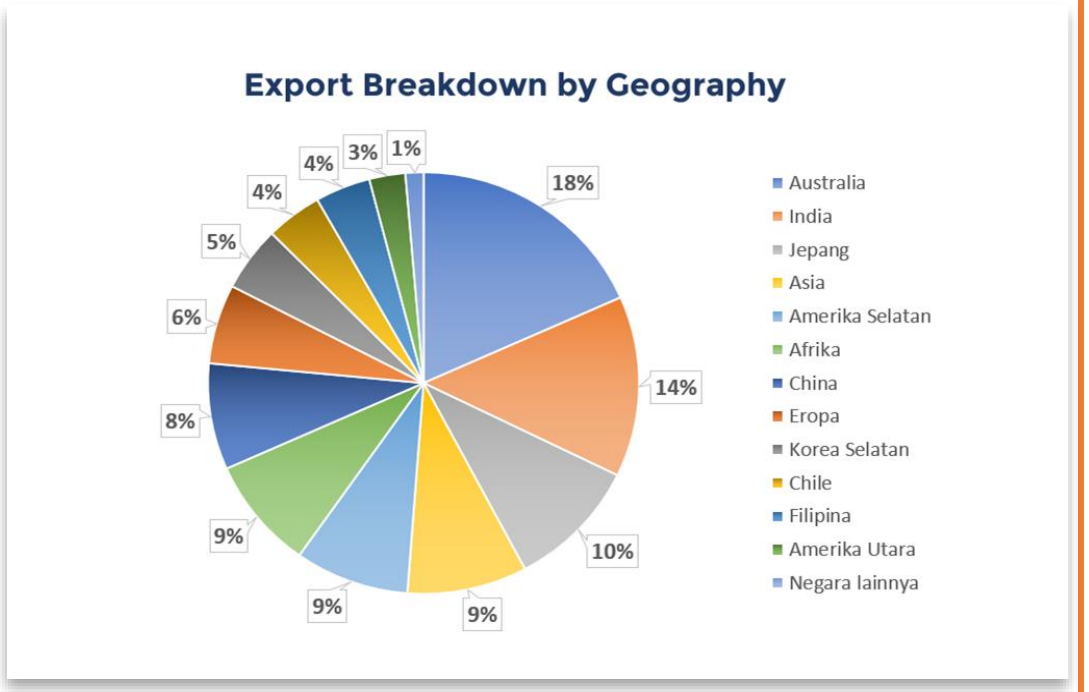
PETROCHEMICAL

Urea | 3,43 Million MTPY
Ammonia | 2,74 Million MTPY
NPK | 300.000 MTPY

MARKET SHARE 2022



EXPORT BREAKDOWN



PRODUCTION CAPACITY AND SUPPORTING FACILITIES

Plant 1A

Urea : 570k MTPY
Ammonia : 660k MTPY

Plant 2

Urea : 570k MTPY
Ammonia : 595k MTPY

Plant 3

Urea : 570k MTPY
Ammonia : 330k MTPY

Plant 4

Urea : 570k MTPY
Ammonia : 330k MTPY

Plant 5

Urea : 1.150k MTPY
Ammonia : 825k MTPY

Plant 7

NPK Fusion : 200k MTPY
NPK Blend. : 100k MTPY

3 Ammonia Tank
100k Ton

6 Urea Bulk Storage

6 Jetty
Up to 55k DWT

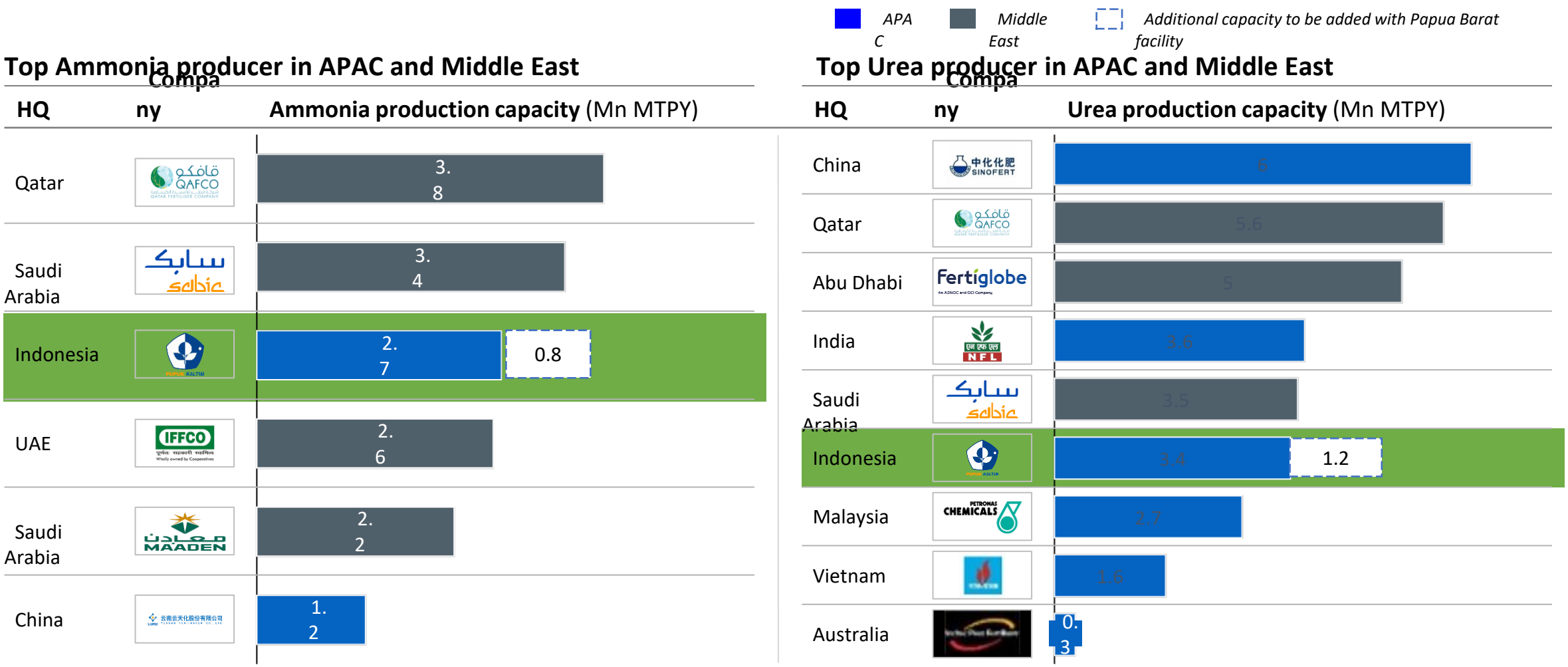
Coal Boiler
560 Ton per Hours

Accredited
Laboratory

Plant Maintenance
Service

PKT obtained Level One System Status for Bulk In-ship Fertiliser Certificate from Department of Agriculture, Fisheries, and Forestry of Australia in 2022; allowing us to export fertilizers to Australia with no obligation to conduct inspection

PROMINENT UREA AND AMMONIA PRODUCER ACROSS APAC AND MIDDLE EAST



Readiness to capture future demand through further production expansion

Source: PKT, Fertecon, Press search

Copenhagen Atomics Company Profile

We enable a paradigm shift for nuclear energy

Copenhagen Atomics Waste burner

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The energy source of the future

A metal from the Periodic Table

Thorium

A single ball of thorium metal can supply you with all the energy you need your entire life.

$100

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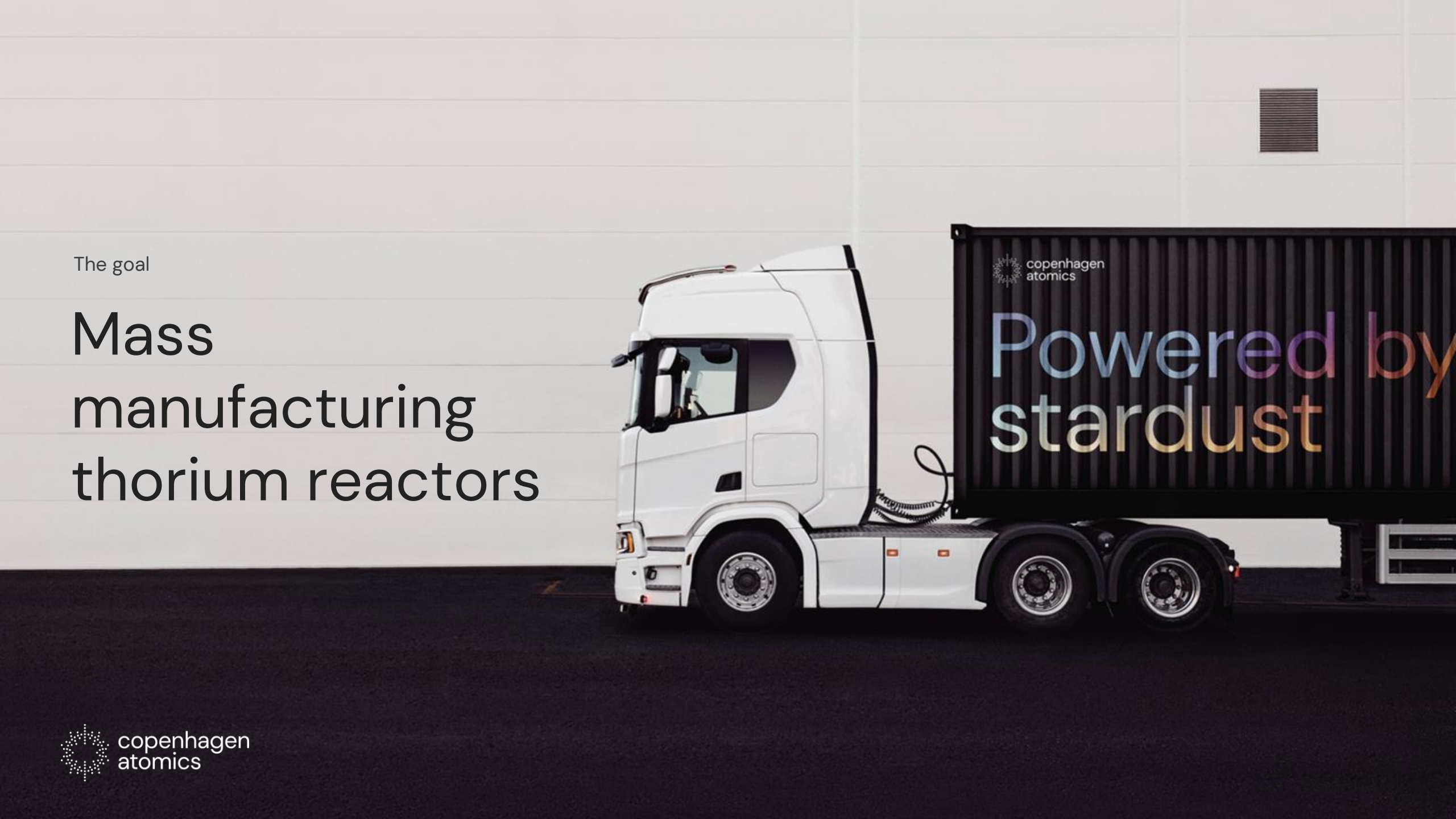
The goal

Mass manufacturing thorium reactors



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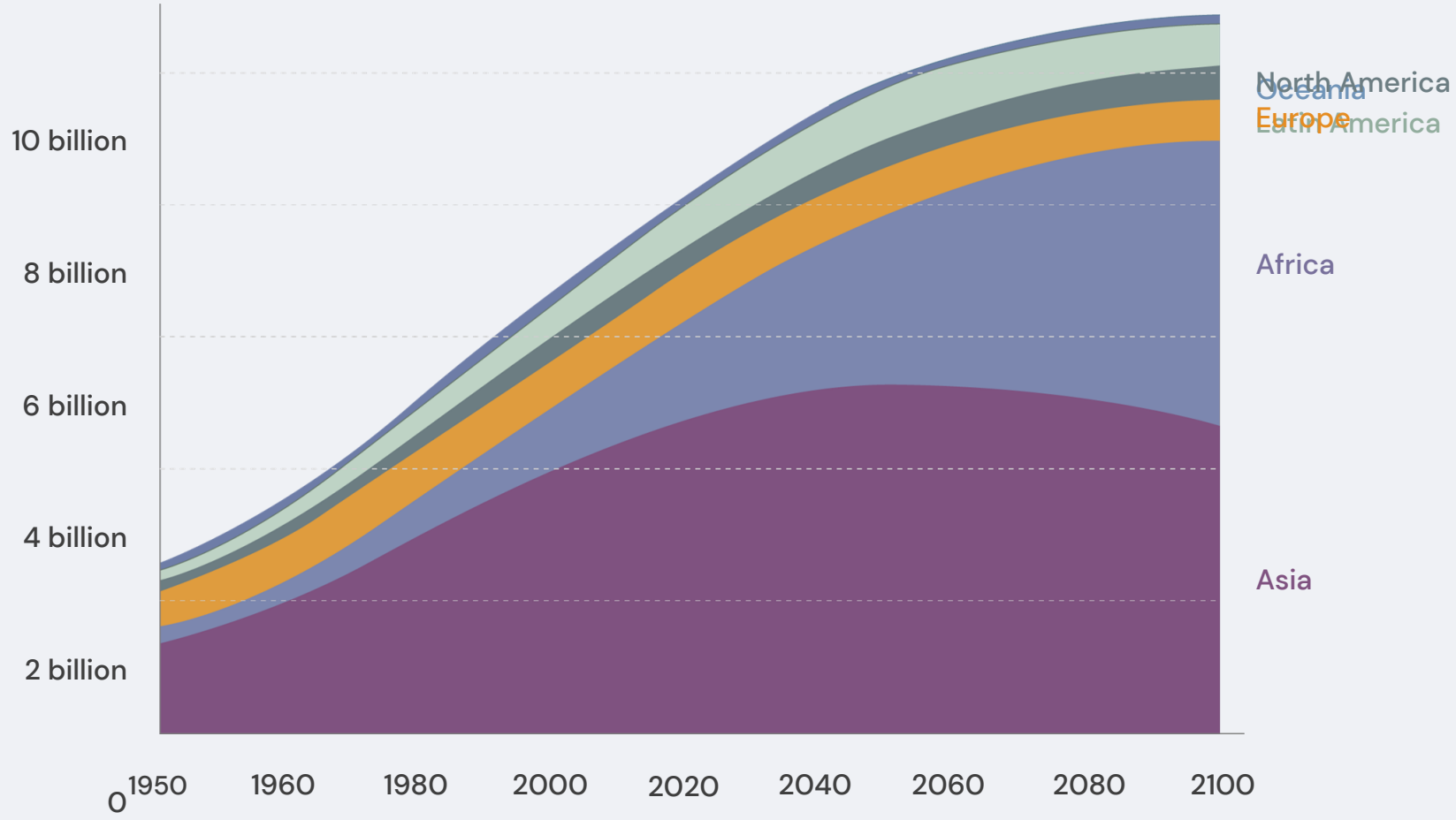
https://youtu.be/27IntvWo4mo

The ultimate problem

Human population growth



Source: HYDE (2016) & UN, WPP (2019), OurWorldInData.org

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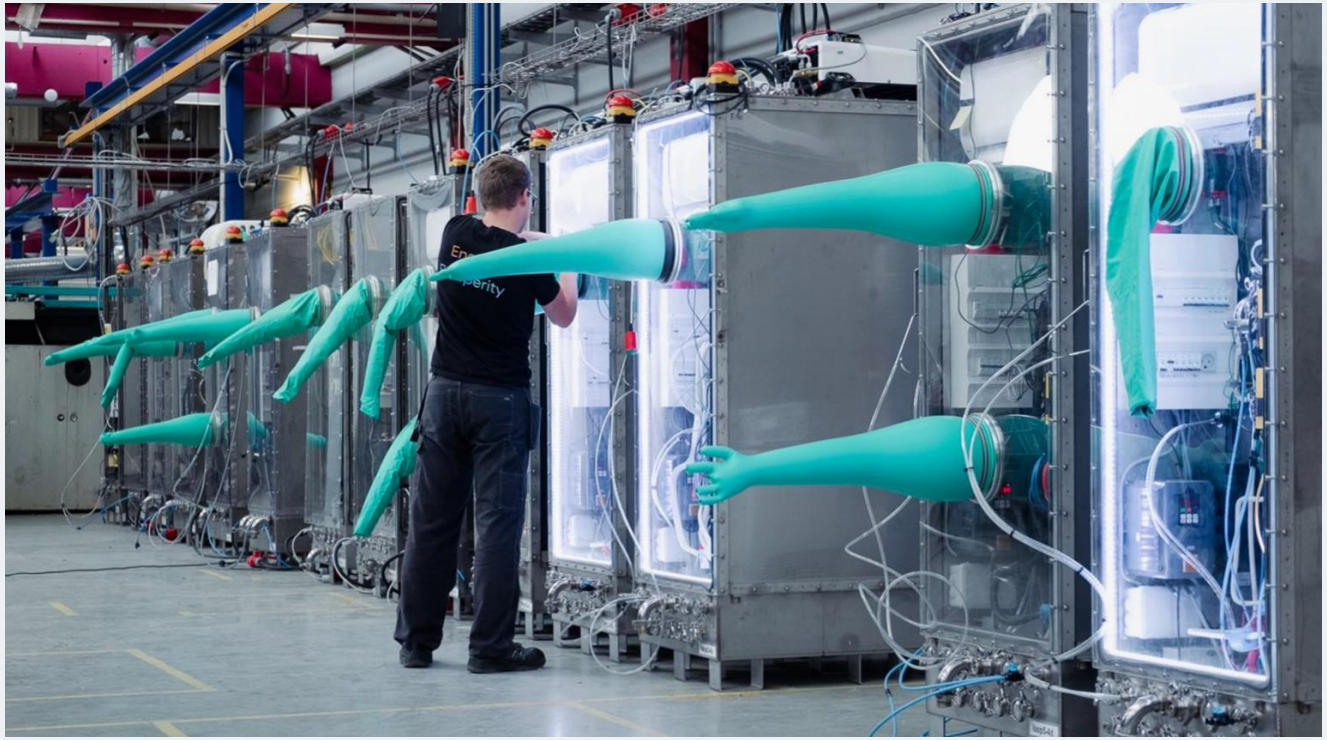
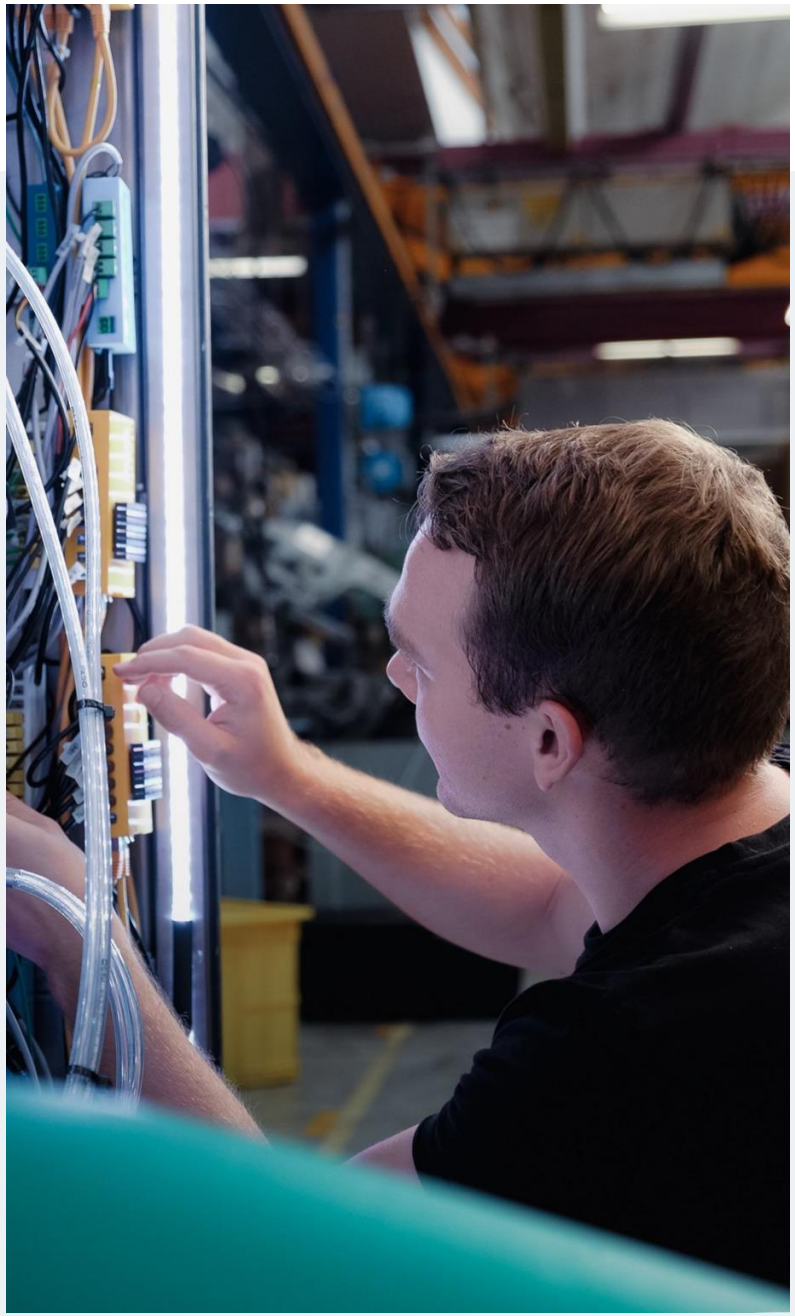
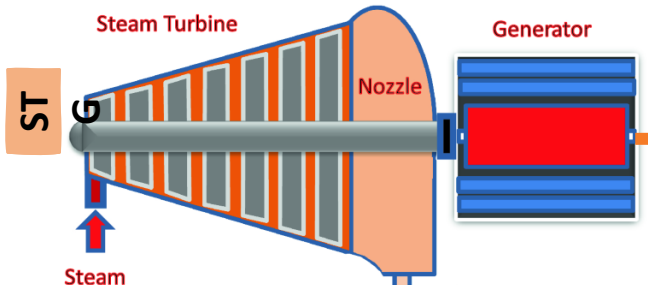




We are already building the first prototype reactor in Copenhagen

Project Description

Clean Ammonia powered by Thorium



Electricity

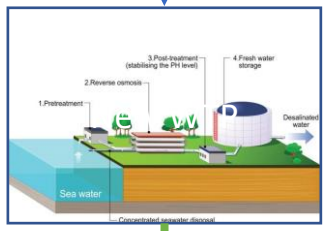
Air

O_2

Electrolysis (SOEC)

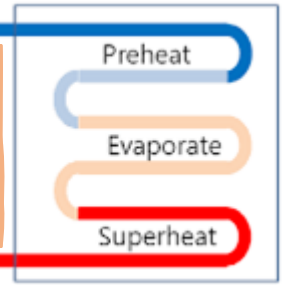
Seawater

New WTP



Condensate /BFW

Molten Salt Boiler

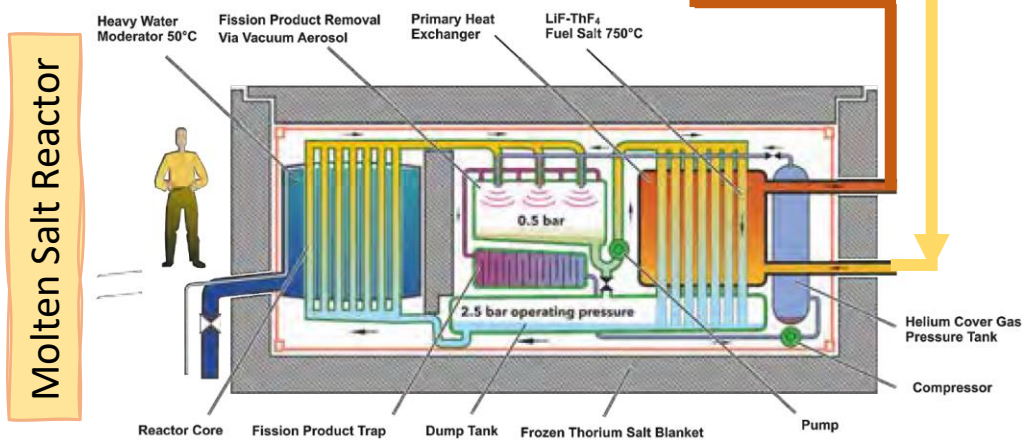


Cold Salt

Hot Salt

Demin water

Syn Gas



S-300

Steam for SOEC

Boiler

CW

NH3(l)

NH3(l)

Ammonia Plant

Makeup compressor

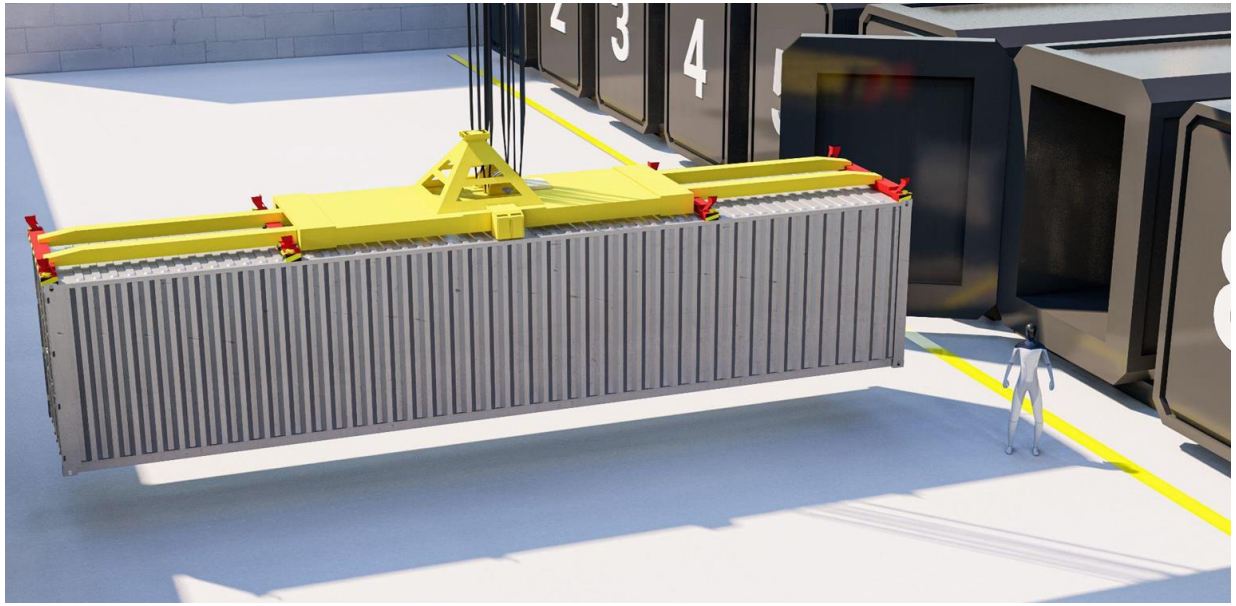
Recycle compressor

CW

Clean Ammonia

Visualisation of a 1 GW power plant

A conceptual visualization of a 1GW Power plant


2
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4


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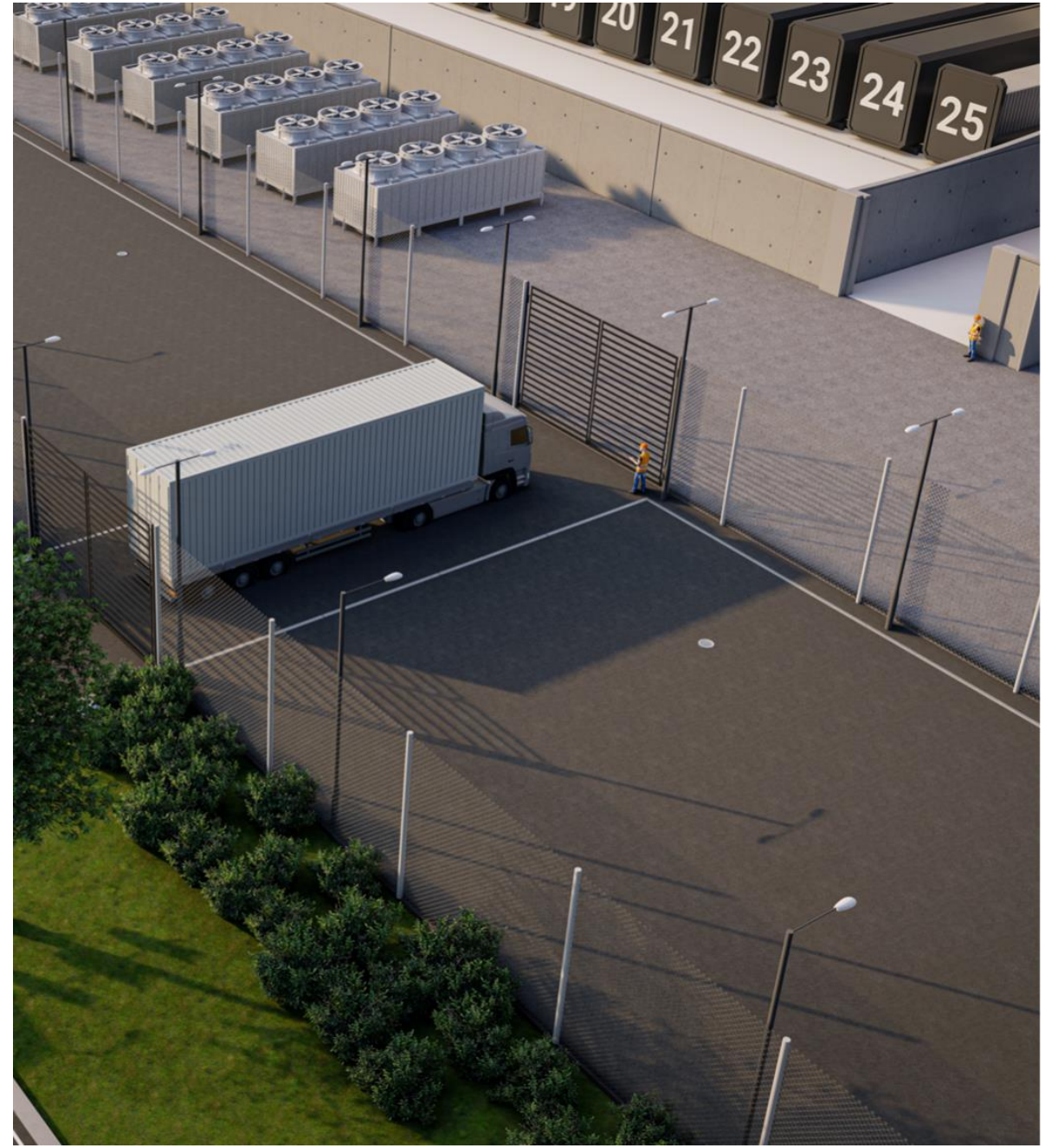
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24
25

A conceptual visualization of a 1GW Power plant


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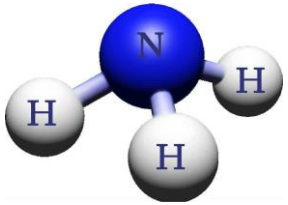
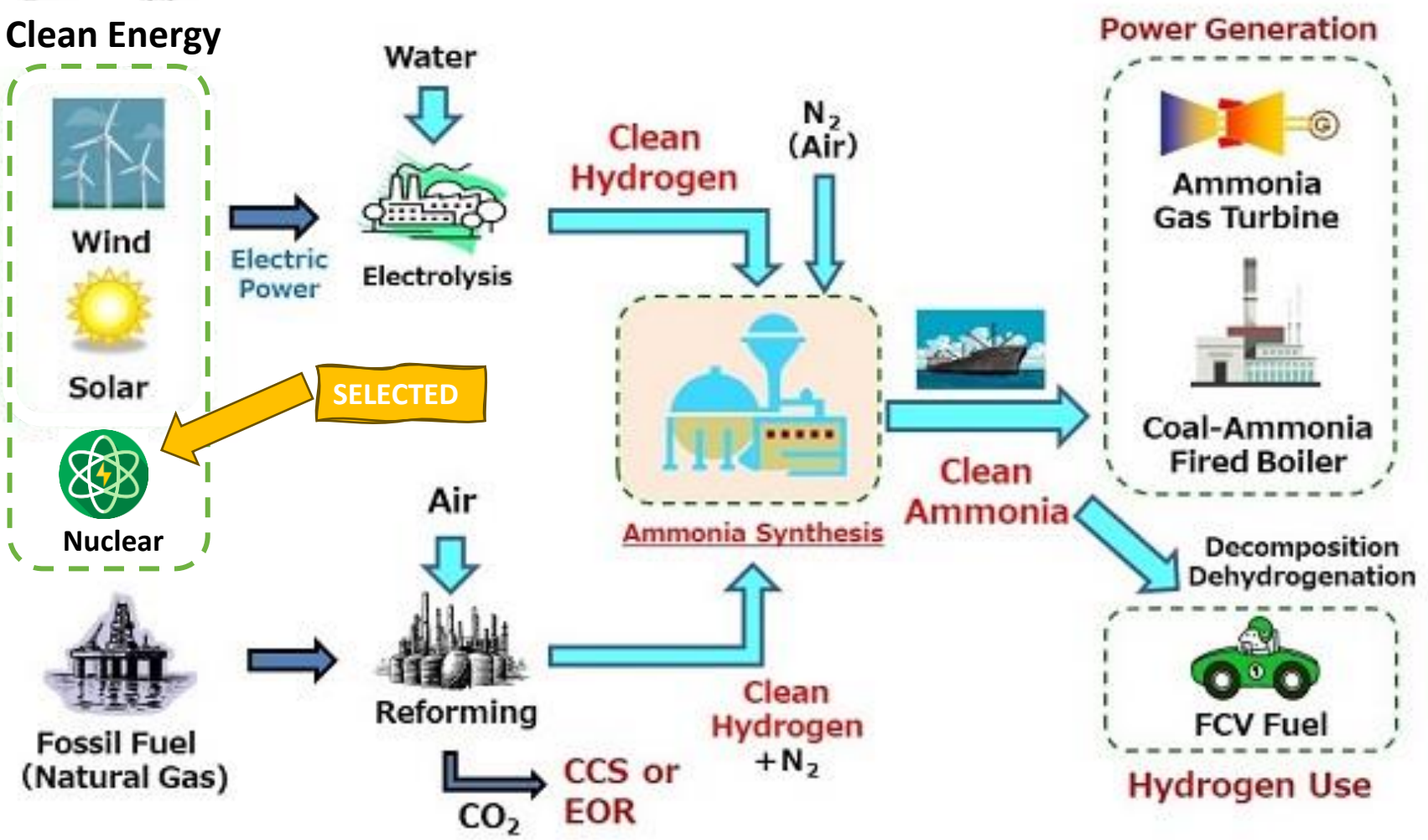
Clean Ammonia

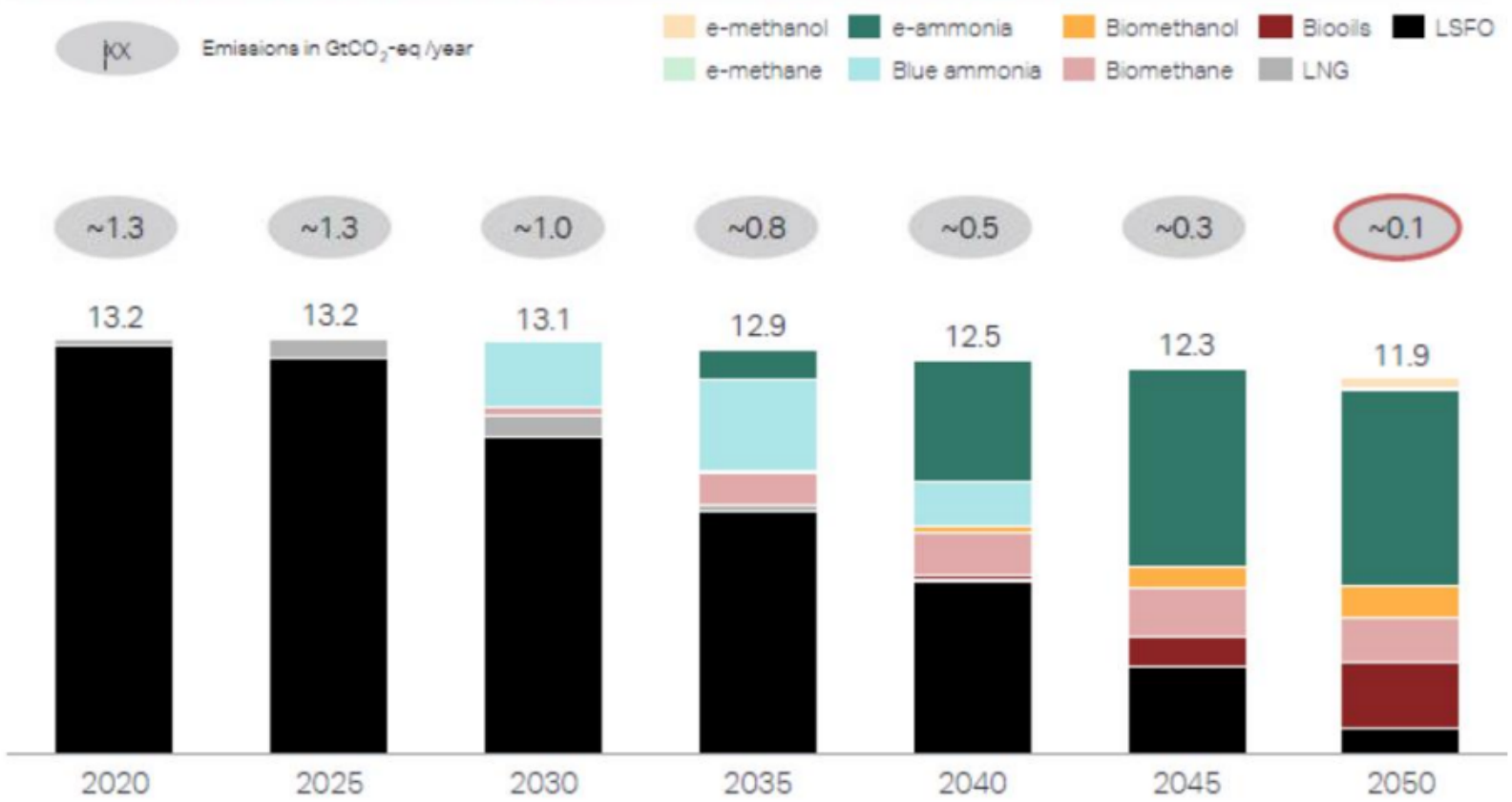
Clean Ammonia



Clean Ammonia means Ammonia which was produced without emitting CO2.

The CO2 emitted will be sequestrated or completely not involving Hydrocarbon in the process by using Renewable Energy





DNV (Det Norske Veritas-an international accredited registrar and classification society, headquartered in Høvik, Norway), in their report Energy Transition Outlook 2019: Maritime Forecast to 2050, mentions that the emission reduction targets set by the International Maritime Organization (IMO) can be met through innovative design using ammonia as an alternative fuel. Widespread commercial adoption of ammonia fuel would begin in 2037; ammonia would be the dominant fuel choice for new ships by 2042; and would represent 25% of the maritime fuel mix by 2050.

This represents new demand for roughly 120 million tons per year of green ammonia by 2050.

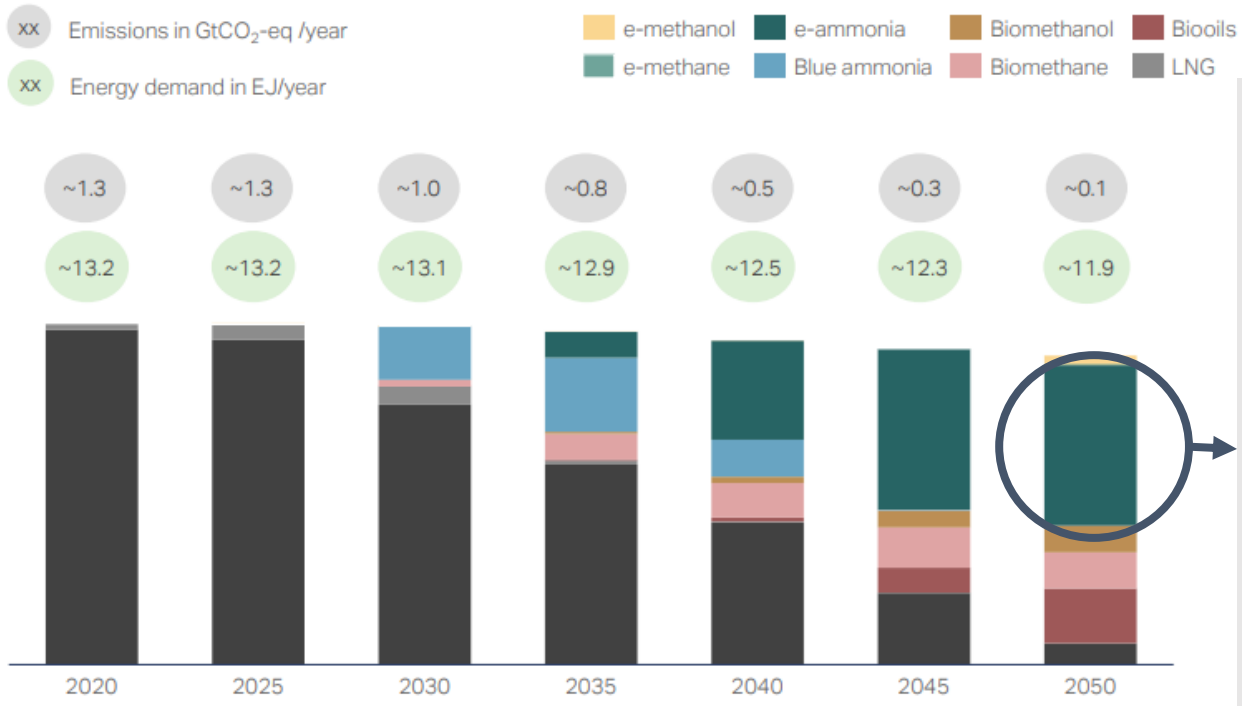
60% of all ocean going ships expected to run on green ammonia by 2050

Current market is almost solely based on natural gas and needs to adopt to a new low emission reality

- Ammonia is currently used as fertilisers. But the essential services ammonia provides come at a cost for the world's climate, ie. a green transition is also expected here
- Ammonia production accounts for about 2% of total final energy consumption, resulting in a CO2 emission equivalent to the total emissions of South Africa's energy system

- In addition to being used as fertiliser Green Ammonia is also predicted to be the backbone for decarbonising international shipping in the medium and long term.
- While ammonia is corrosive and highly toxic if inhaled in high concentrations, ammonia has been handled safely for over a century

Huge market growth potential



Source:Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping, Industry Transition Report, October 2021

- Total energy demand by 2050 is 11.9 EJ/year
- 1 EJ = 278 TWh
- With an energy density of 5.17 MWh per metric ton (LHV), this 11.9 EJ annual demand would require roughly 640 million tons of ammonia per year.
- 60% of total demand is expected to be Green Ammonia, hence **demand is expected to 380 million tonnes per year**
- To produce ammonia in these amounts approx 450 GW of electricity is needed.
- Assuming CA can get 15% of the market, it would require that CA manufactures 300 reactors per year, every year from 2050 and forward.

Reactors on Land VS

Retrofit, Barge & Ship

	Price (LCoE)	Market size	Insurance	Development Speed	Fuel choice
New build on land	**$20 / MWh**	**5000 GW**	**$**		**Any**
Retrofit on land	$40 / MWh	500 GW	$$		Depends
On barge	$40 / MWh	500 GW	$$$		Likely limited
Ship propulsion	$100 / MWh	50 GW	$$$$		Clearly limited

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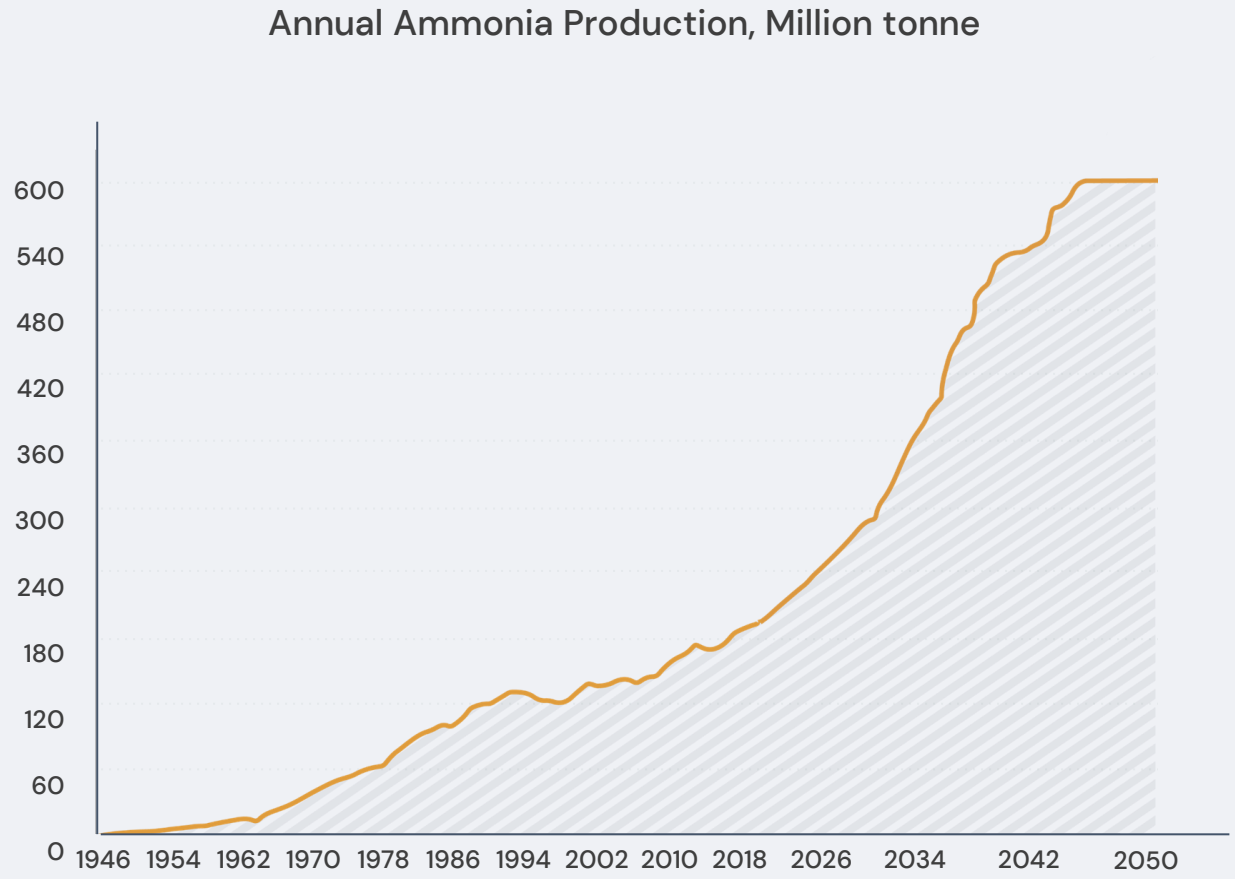
The global ammonia market needs to turn green

The market is expected to triple before 2050

Green ammonia production needs 600 GW of electricity, twice that of what Europe is producing today.

Ammonia is a direct replacement fuel for diesel in ships, trucks, trains and heavy equipment.

Ammonia has been used as fertilizer and for refrigeration systems for more than 80 years. Well established supply chains.



Today's market is approx. 220 million ton per year.

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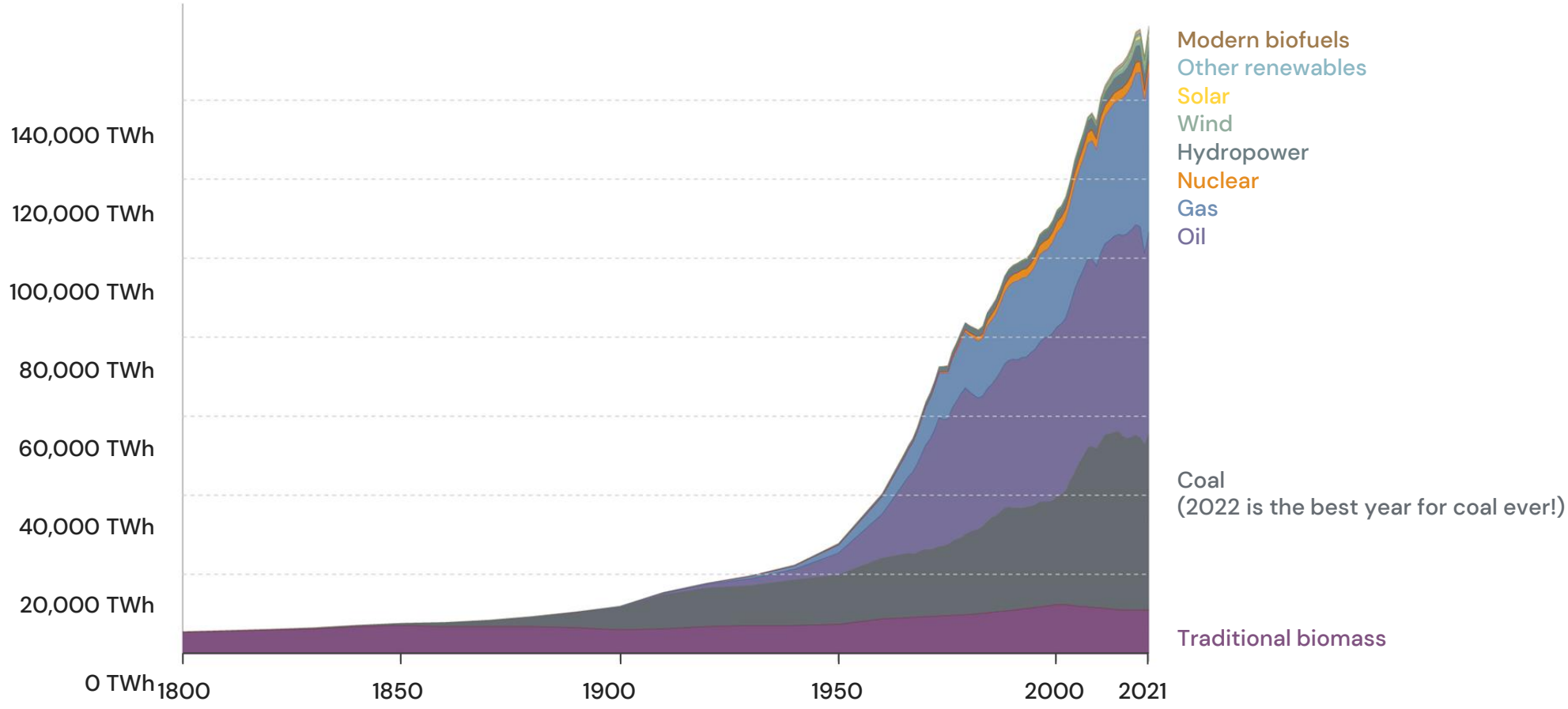
Thorium Molten Salt Reactor

Global primary energy consumption

1800–2021



Source: Vaclav Smil (2017) and BP Statistical Review of World Energy

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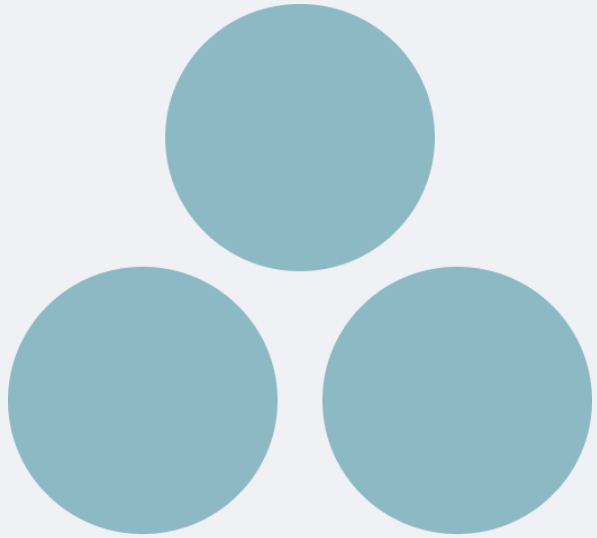
We will never run out

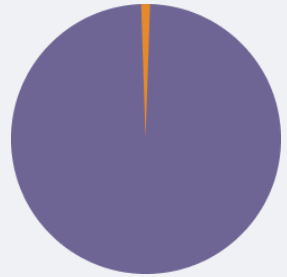
Thorium is more abundant than uranium

Classic nuclear uses U235 and we may run out of it in 200 years time. Therefore it is not considered a renewable energy source.

However thorium can make a breeder reactor and we will run out of materials to build wind and solar before we run out of thorium and the materials needed to build Copenhagen Atomics power plants. Therefore CA reactors are considered über-renewable energy.



Natural Thorium
100% thorium-232



Natural Uranium
99.3% uranium-238
0.7% uranium-235

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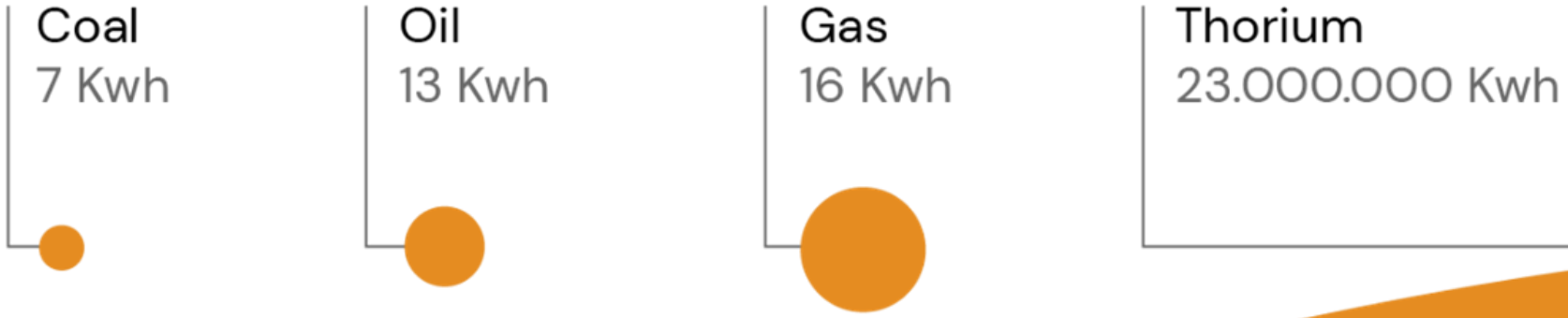
Kilowatt hour (kWh) energy
Generated from 1 Kg fuel



When we convert thermal energy to electricity and sent into the electricity grid, then 50-80% of the energy is lost before it reaches your electricity sockets. This is true for all four fuel types.

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The Molten Salt Reactor design

Simple, efficient & inherently safe

The reactor design has three barriers between radioactive salts and nature.

The system is not pressurized.

If the pump is stopped the salt drains in the dump tank by gravity and the chain reaction stops within seconds.

Heavy water is used as the moderator and this helps the Onion Core® to outperform any other reactor design.

The energy is transferred through heat exchangers and delivers heat via molten salt at 560C to the customer.

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The Onion Core®

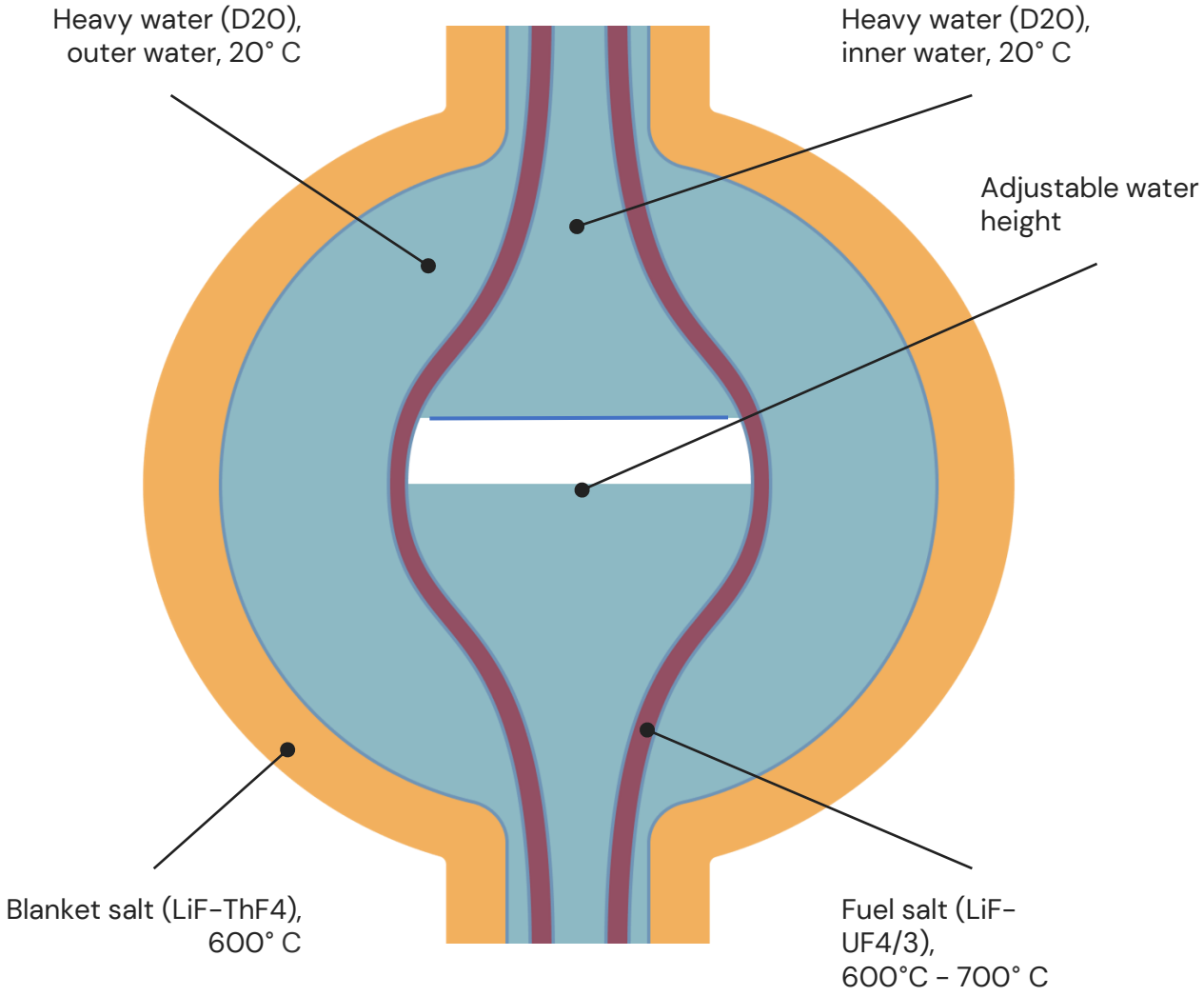
Cross-section view

The reactor core is patented and under the trademarked Onion Core®.

It has ~1200 liters of heavy water, 200 liters of fuel salt and 2000 liters of thorium blanket salt.

It can achieve remarkable neutron economy and breeding in thermal spectrum, which has the potential to outperform any other reactor design from the past.

This requires almost all fission products are removed online and core are constructed out of carbon composites.



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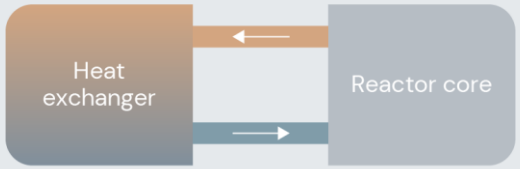
The fundamentals of an MSR

An MSR separates itself from a traditional LWR in several ways resulting in a safer and more efficient reactor design

Similarity with an LWR



Nuclear energy fundamentals

An MSR is based on the same principles as a traditional nuclear reactor:

- A primary coolant circulate through a reactor core where it is heated
- The coolant is then sent through a heat exchanger that transfers the thermal heat to water
- The water boils and generates steam that drives turbines
- The primary coolant returns to the core and the process repeats

MSR differentiation from a traditional LWR

CA operates molten salt up until 650 °C

Primary coolant

- An LWR uses water, which needs to be pressurised to remain in liquid form
- An MSR uses molten salt, which is liquid at high temperatures at atmospheric pressure removing the risk of explosions

Can expand | Can be drained | Binds radioactive elements

Fuel characteristics

- In an LWR, the fuel (enriched uranium) is in solid form and stationery in the core
- In an MSR, the fuel is part of the liquid molten salt used as primary coolant
- – The liquid form allows the fuel to expand in case of overheating, which slows the chain reaction and lowers the temperature of the salt
  – The liquid fuel can be drained to a dump tank if necessary
  – All radioactive elements are bound to the salt and no dangerous gasses are generated

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Corrosion in molten salt

2000 hours in purified and unpurified FLiNaK salt at 600 °C

	Raw unpurified salt	Purified salt
Before		
After		

Very low corrosion rate

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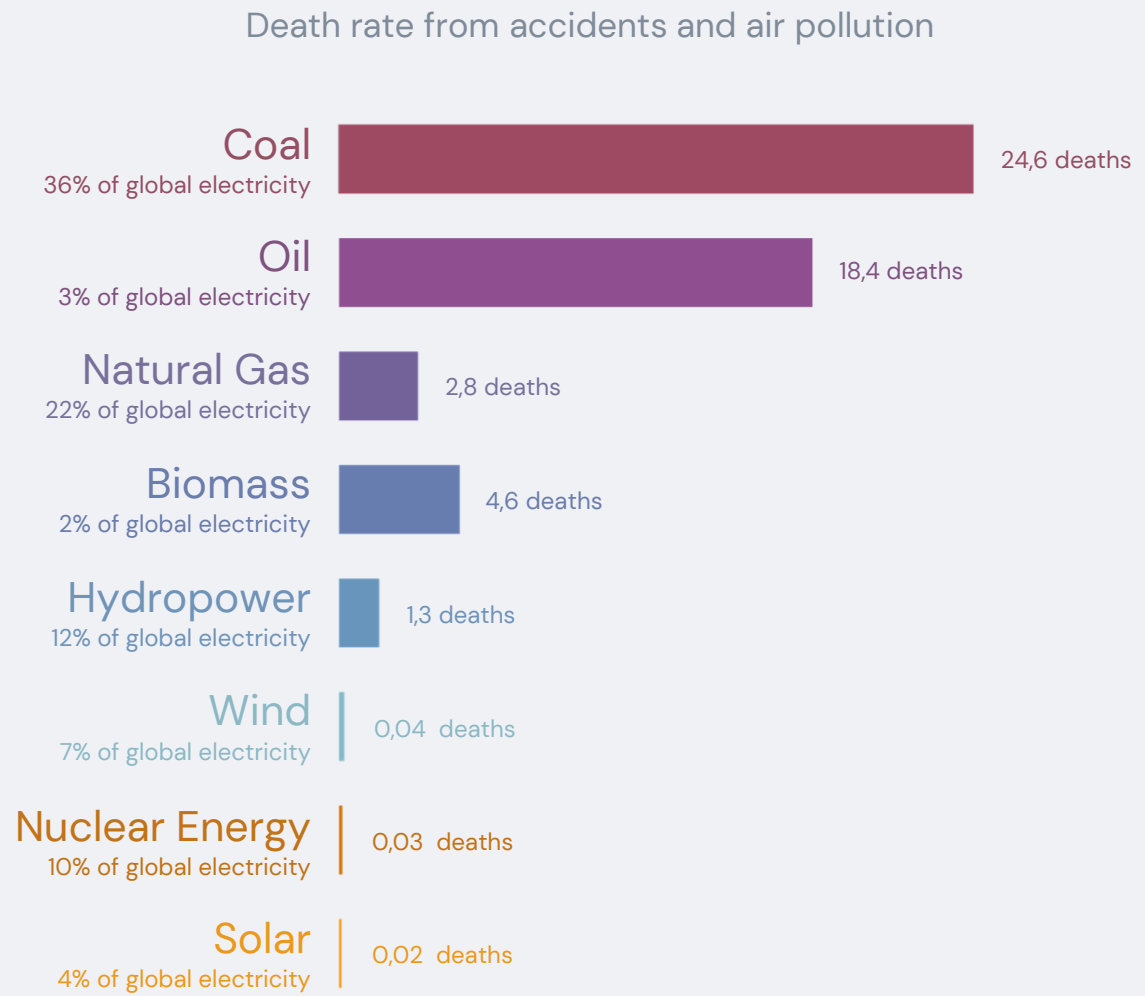
What are the safest energy sources?

Measured as deaths per terawatt-hour of electricity production.

1 terawatt-hour is the annual electricity consumption of 150.000 people in the EU.



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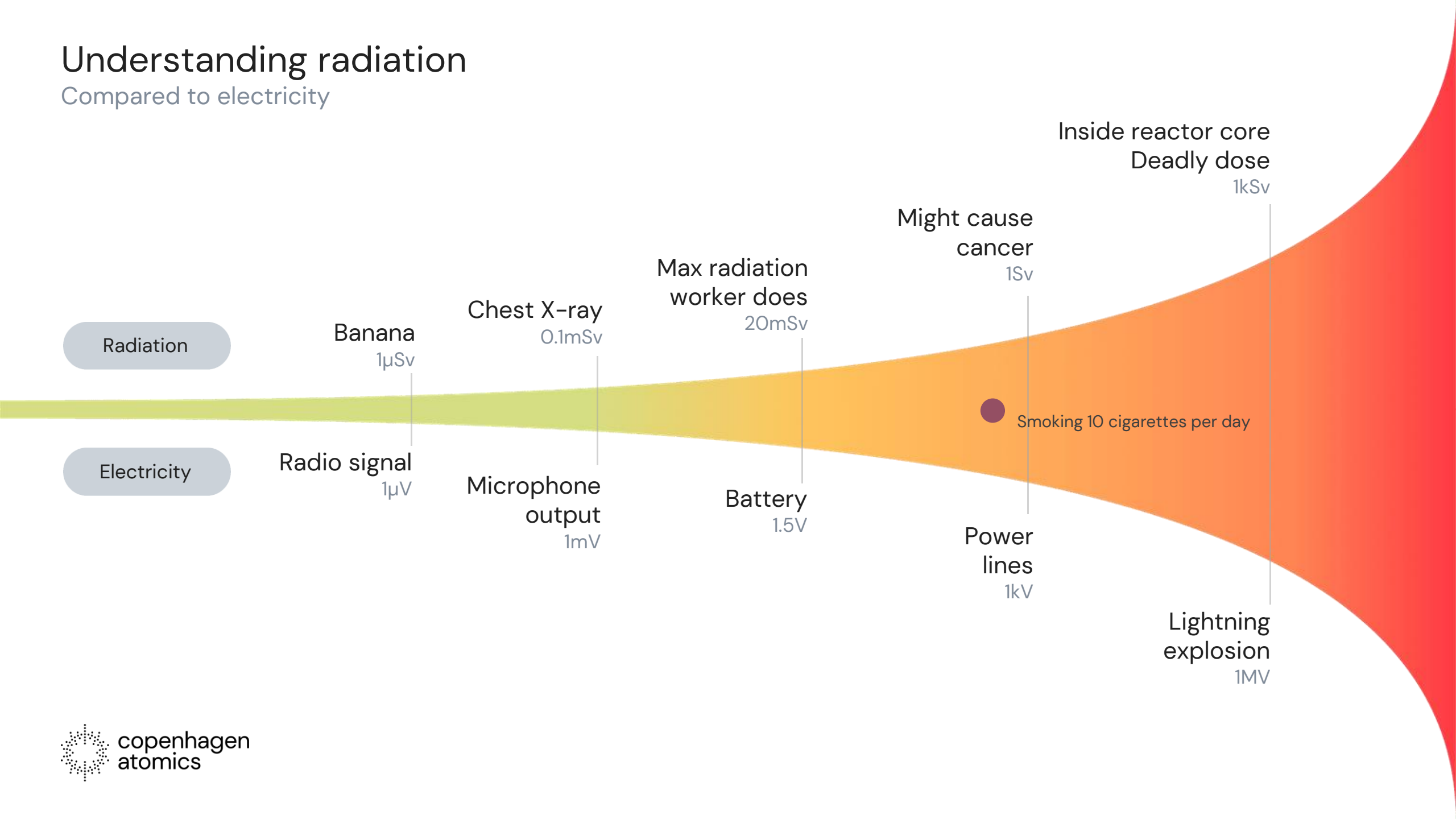
Understanding radiation

Compared to electricity



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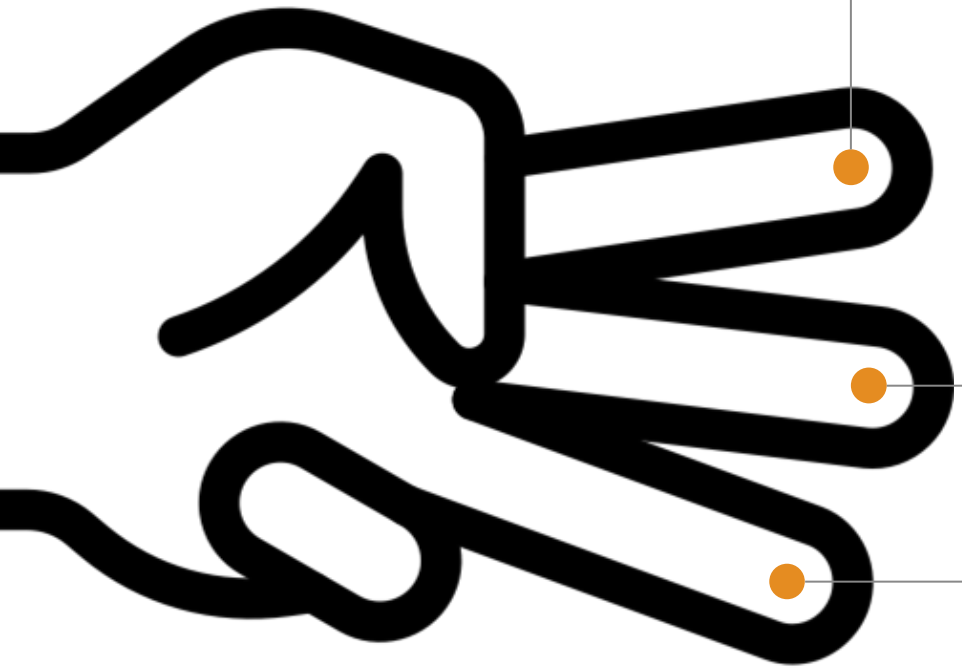
Nuclear technology paradigm shift

This is a new category of commercial nuclear energy!



Lowest cost of energy.
We can match anyone else on price!

No taxpayer investments. Copenhagen Atomics, finance, build, own and operate the nuclear power plant and we decommission it after end of life.

Copenhagen Atomics reactors are able to **burn nuclear waste** and reduce storage from 100,000 down to 300 years.

Ten times more energy can be extracted from spent nuclear fuel in CA reactors than in classic reactors first use.

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Thank You