Development of the Thorizon One molten salt reactor

Kiki Lauwers
Netherlands, June 5th 2024

NRG

Nuclear. For life.

THORIZON

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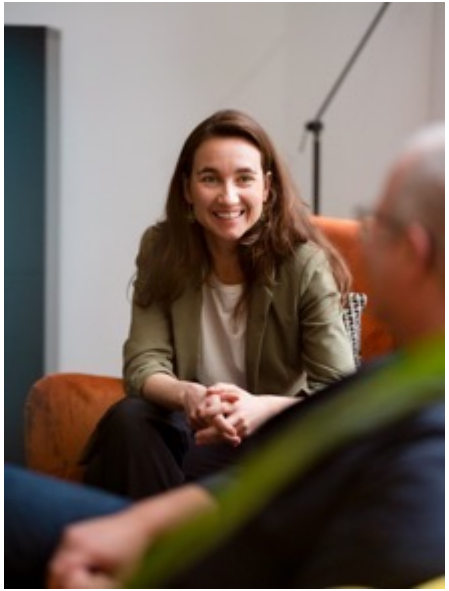
May 2024

FRANCE 2030

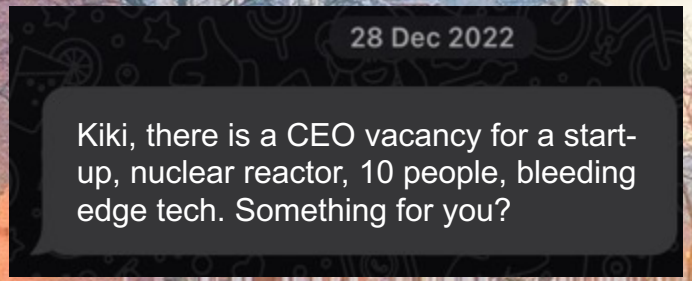
Speaker introduction

Kiki Lauwers

- CEO of Thorizon since May 2023
- Obtained Masters' degree in Aerospace Engineering at Delft University of Technology and MBA at INSEAD business school
- Started career as strategy consultant with McKinsey & Company specializing in advanced industries
- Over 15 years of experience in technology strategy and management including scale-ups (leading innovation at Bol.com)
- Government Board Member of the SNETP (Sustainable Nuclear Energy Technology Platform)



How my journey with Thorizon started...

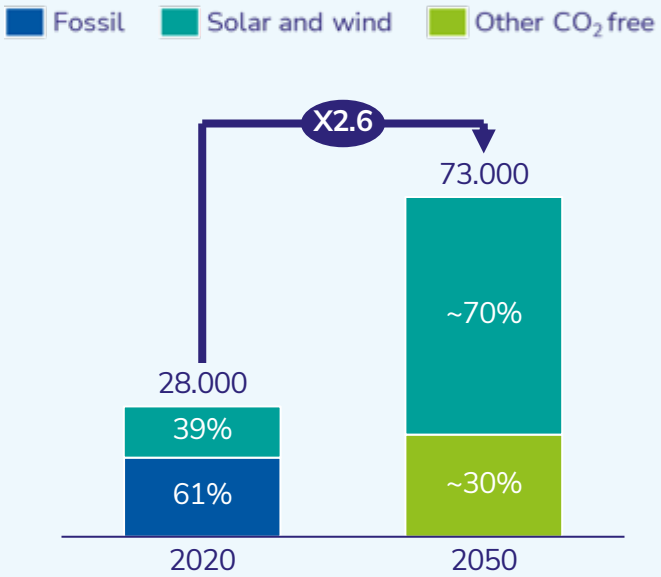


We need to revolutionize power generation beyond solar and wind

Decarbonizing electricity production

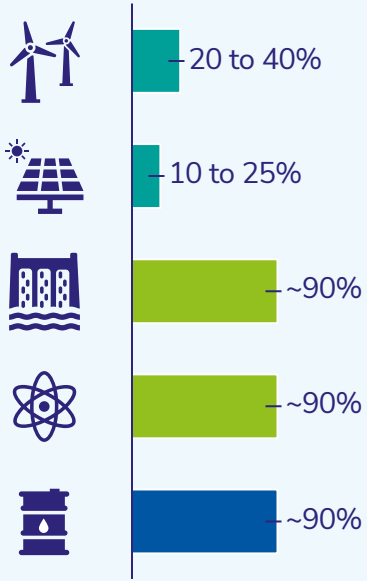
Power demand will grow 2.6X until 2050, with a large role for solar and wind

Global electricity production - TWh



Solar and wind are highly intermittent, and always need reliable, flexible capacity as a complement and back-up

Output factor (% of capacity)



- Wind and solar have low output factors due to their highly intermittent nature
- Other power sources are essential as a complement to provide 24/7 energy security and to stabilize the grid
- The ideal complement is not only reliable, but also controllable in terms of electricity generation

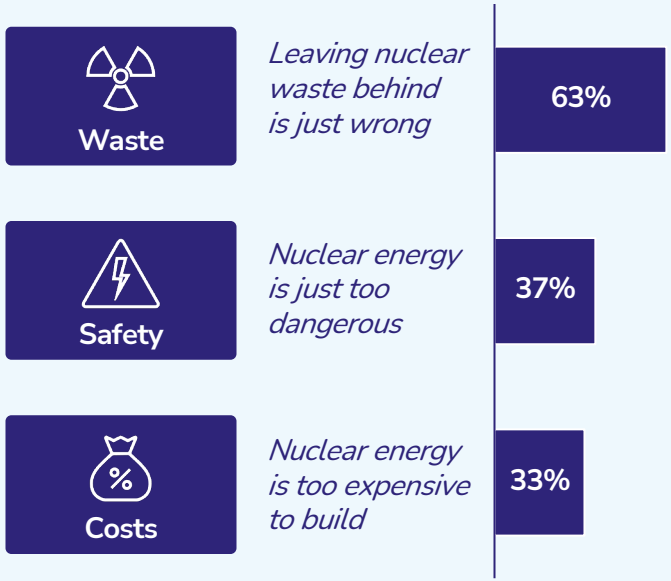
Nuclear reactors are crucial assets in a secure global pathway to net zero

Source: IEA Energy Outlook 2022 – Net Zero scenario, https://www.iea.org/reports/nuclear-power-and-secure-energy-transitions/executive-summary, COP 28

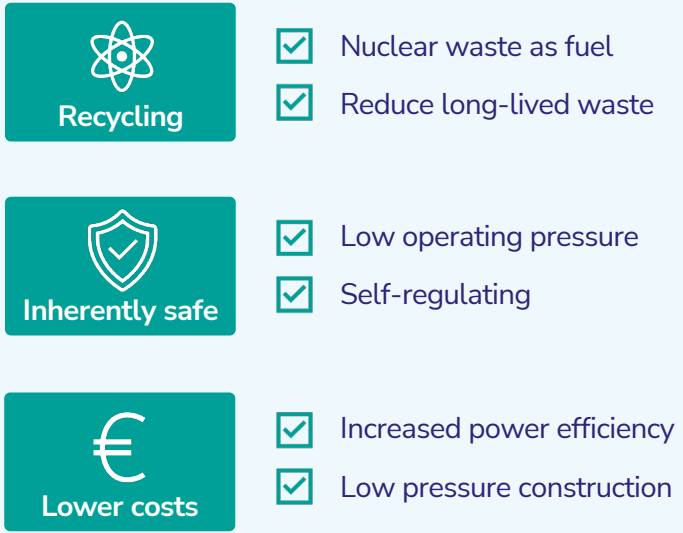
Molten salt reactors can unlock the full potential of nuclear energy

The potential of molten salt reactors

People are concerned about waste, safety and costs
% of correspondents agree / strongly agree



Molten Salt Reactors are seen as a game-changer in the industry



Source: Survey "The world wants new nuclear" - May 2023; Status of Molten Salt Reactor Technology (IAEA); team analysis

Our mission: The Thorizon One is the missing piece in the energy transition

The Thorizon One

- Flexible carbon-free energy
- Reduction of long-lived waste
- Walk-away safe
- Cost competitive

If Molten Salt Reactors are such a great idea, where are they?

History of Molten Salt Reactor Technology

The problems to be solved

1
Material Integrity

Impossible to find and license reactor materials for a lifetime of >60 years due to effects of corrosion, heat, and irradiation

2
Fuel Management

Large volume of salt is needed for operations and salt is difficult to transport and handle after use.

Thorizon solved the two main issues in molten salt reactor realization due to its innovative cartridge-based core

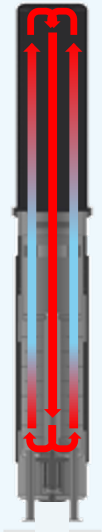
Innovative cartridge based-core

1 Material Integrity

2 Fuel Management

The solution

- Salt is contained in cartridges that are replaced every 5 to 10 years.
- Containment materials are already qualified for nuclear use.
- Fuel volume is compartmented and contained in modular cartridges all the time.
- Cartridges allow for transport and handling of fuel.



Thorizon's concept: combining molten salt cartridges into a set creates a critical reactor core

- In a molten salt reactor, the salt acts as both the coolant and the fuel
- Cartridges contain all primary system components: salt, pump, heat exchanger
- When the pump is active, the molten salt is circulated
- Only when cartridges are together and salt is circulated, fission energy is generated through neutron interaction between the cartridges

Patented by Thorizon, positively reviewed and recognized by industry experts as very promising

Source: : IAEA Status of molten salt reactor technology, team analysis

Illustration of the concept

- Cartridge contains all primary systems: salt, pump, heat exchanger

- When the pump is active, salt is pumped upwards through the cartridge

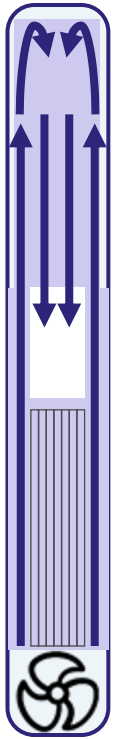


Illustration of the concept

- Only when cartridges together are active, there is a critical configuration at the top of the reactor

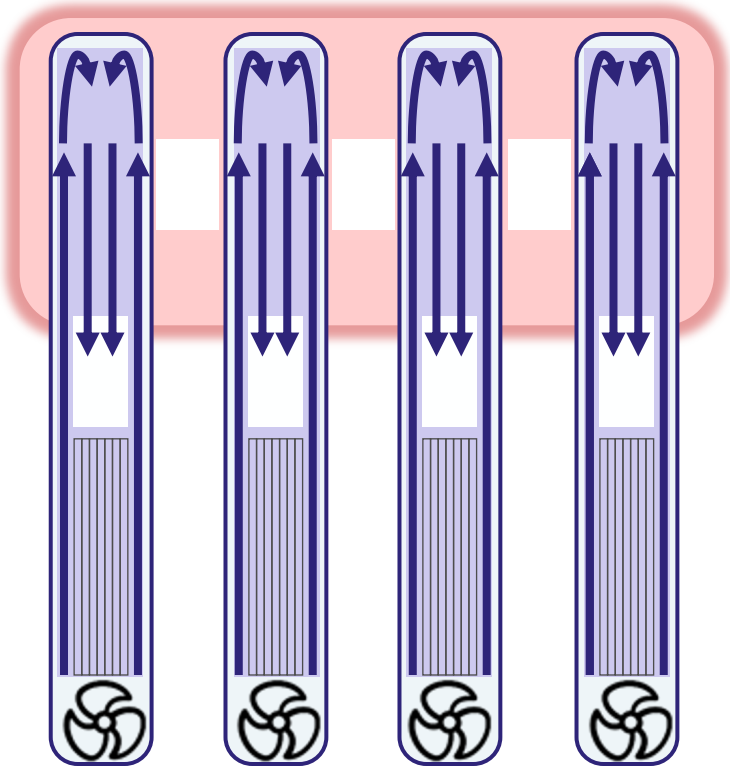


Illustration of the concept

- Only when cartridges together are active, there is a critical configuration at top of the reactor

- Heat is extracted through the heat exchanger on the lower part of the cartridge

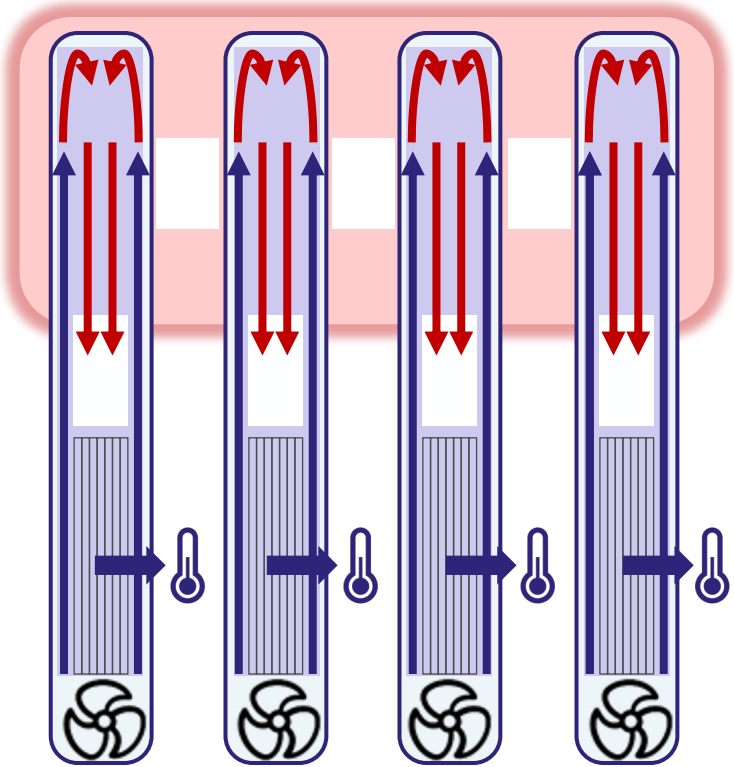
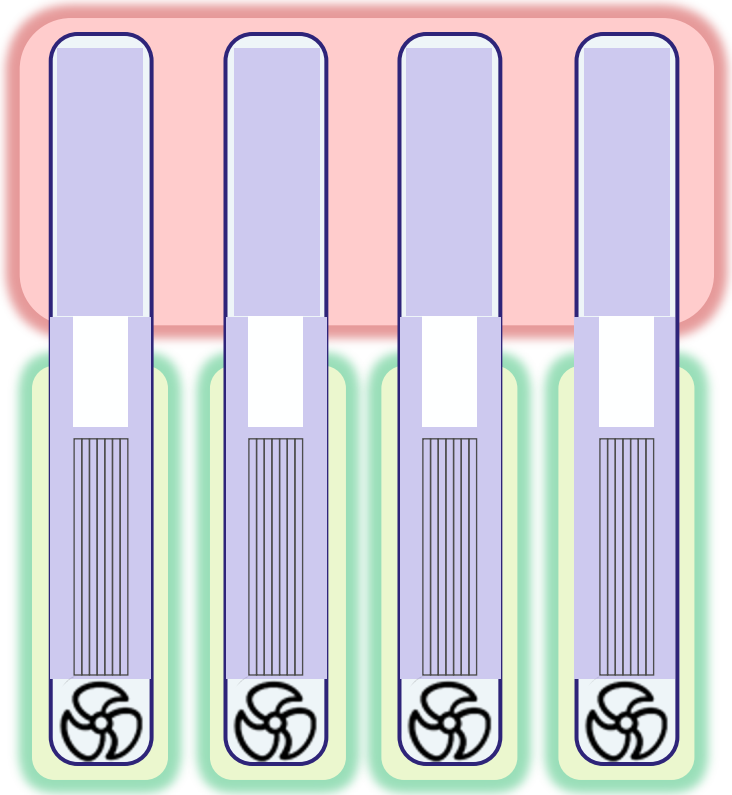


Illustration of the concept

- When the pumps stop, the salt drops to the bottom of the cartridges

- The fission reaction stops, the reactor is not critical anymore



Resulting in superior technology in terms of safety, feasibility and circularity

Safe, Smart & Circular

Safe

Walk-away safe - Safety by design and gravity

Low pressure - Always operates under low pressure

Self-regulating - Temperature increase slows down reaction

Smart

Solves material degradation - Allows use of existing materials

Easy to handle - Cartridges can be replaced and transported

Continuous upgrades - enhance performance with core exchange

Circular

Carbon free energy - Providing ample, CO_2 free electricity or heat

Nuclear waste as fuel - More energy from spent nuclear fuel

No long-lived waste – Acting as a nuclear waste burner

Our technology leverages the full potential of molten salt and the modularity of the cartridges

The Thorizon One is an attractive proposition for nuclear operators

The Thorizon One reactor

Facility includes a 250MWth reactor island and a salt storage system

THORIZON ONE

A flexible turnkey, full-service asset with attractive economics into the existing value chain

Highly flexible asset

- 50-300 MWe flexible power, 100 MWe baseload
- Multiple units can be combined per site
- 550°C heat for industrial processes

Full-Service turnkey delivery

- Project management from pre-feasibility to commissioning
- Scalable reactor design adapted to site requirements
- Fuel and cartridge lifecycle management

Attractive economics

- Targeting LCOE of € 60 per MWh
- Industrialized cartridge production in series offsite
- Basic reactor building, no pressure dome, no primary system

Via our design choices, licensing strategy, way of working and partner strategy we focus on optimizing our path to market

A realistic path to market

We have a realistic approach to ensure our ambitious timeline

Realistic licensing path

- Joint and ongoing engagements with Dutch and French regulatory bodies
- Following existing regulations for nuclear sites
- Use of nuclear qualified materials

Deliver design step by step

- Safety by design is leading for our entire team
- Agile, solution driven team with option to scale up through trusted partners
- Best practice systems engineering approach to ensure requirements are met

Leading supply chain partners

- Co-development with industry leaders across Europe on key components
- Strong partnership with Orano, with decades of experience in nuclear fuel recycling and dedicated to molten salt development and transportation

Our approach

We are on track for cartridge demonstration in 2026 to start building the first of a kind Thorizon One by 2030

Development roadmap

~Q3 2022	~Q3 2024	~Q2 2027	~2032
Phase 1 **Initial design**	**Phase 2** **Technology demonstration**	**Phase 3** **Industrialization**	
€ ~ 22,5 mln ✓ System requirements in place ✓ Computational methods in place ✓ Licensing process initiated in NL & FR ❑ Conceptual design ready ❑ Patent portfolio of 3 patents	**€ ~ 125 mln** • Site confirmed for first of a kind reactor • Full scale cartridge prototype tested • Nuclear proof of concept (validation) • Detail design of full reactor island • PSAR obtained, license to build submitted	**€ ~750mln** • Series production of the cartridge • FOAK site preparation • FOAK construction • License to operate • Start of commissioning	

Our approach

We succeed in rapidly attracting and onboarding industry and scale-up talent across Amsterdam and Lyon

Experienced and scalable

Our management team

Sander de Groot
CTO & Co-founder

25yr nuclear research and development

Kiki Lauwers
CEO

15yr tech scale-up and management

Laure Claquin
COO & director France

15yr large nuclear projects & management

Arthur van Wylick
CFO

30+yr finance incl. 15yr scale-ups

Titus Tielens
CBDO

25yr BD, extensive nuclear network

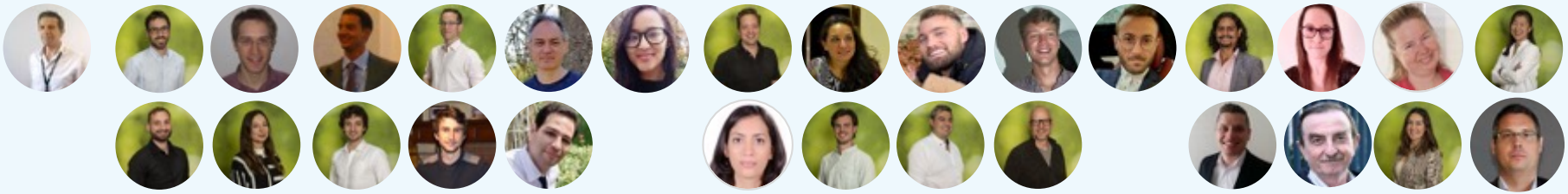
Margriet Hooghiemstra
Chief of Staff

10yr strategy, M&A and business building

- 32% women
- 15 nationalities
- Growing to ~40FTE by Autumn

Our growing team of experts

Safety | Neutronics | Thermal Hydraulics | Mechanical Engineering | Systems Engineering & Prototyping | Chemistry | Program management



We secured important partnerships, and aim to combine the best of France and the Netherlands in our supply chain

Industry leading Partnerships

Secured cornerstone partners that are fundamental for our development

orano

assystem

NRG

TRACTEBEL ENGIE

Strong established relations with exceptional research institutes

cea

centralelille

Université de Lille

DIFFER

TU Delft

TNO

JRC EUROPEAN COMMISSION

Access to the French nuclear and Dutch high-tech manufacturing ecosystem

EDF

framatome

ORKRIDGE

VDL

delmeco

DEMCON

Partnering with peers to accelerate development

naarea

STELLARIA

Thorizon is backed by committed investors and proudly recognized as one of two non-French born companies in France 2030

Backed by committed investors

positron ventures

Participatiefonds Duurzame Economie Noord-Holland

FRANCE 2030

Lauréat

RÉPUBLIQUE FRANÇAISE

INVESTNL

Impuls Zeeland

naarea · newcleo · Jimmy · STELLARIA · otrera · HEXANA · BLUE CAPSULE · RENAISSANCE FUSION · CALOGENA

We are continuously looking for talent, strong partners and investors to join our mission to secure our energy future and combat climate change

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Join our mission

Please reach out in case of questions or suggestions!

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Follow Thorizon on LinkedIn for the latest news!

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Questions?

If you have questions after this briefing, don't hesitate to contact me

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