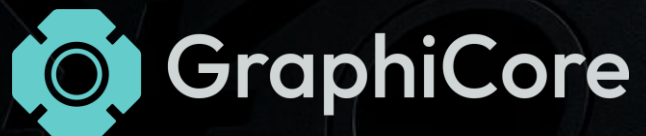


Enabling Graphite-Moderated Reactors Decommissioning



We built a highly competent team of professionals and advisors capable of facing the challenges ahead



Dr. Riccardo Chebac
CEO

- Doctor in Nuclear Engineering from Politecnico di Milano
- 5 years of research and industry experience with WSP, OECD-NEA RWMD and UC Berkeley
- Co-developer of the product and responsible for client relationships



Fabio Vanoni
CTO

- Nuclear Engineer and Research fellow at Politecnico di Milano
- 5 years of research experience in graphite
- Co-developer of the product and responsible for product development



Jonathan Giovannacci
CFO

- Nuclear Engineer from UC Berkeley
- 5 years of industry and strategy consulting experience
- Responsible for business plan design and industrial strategy



Prof. Alessandro A. Porta
Advisor



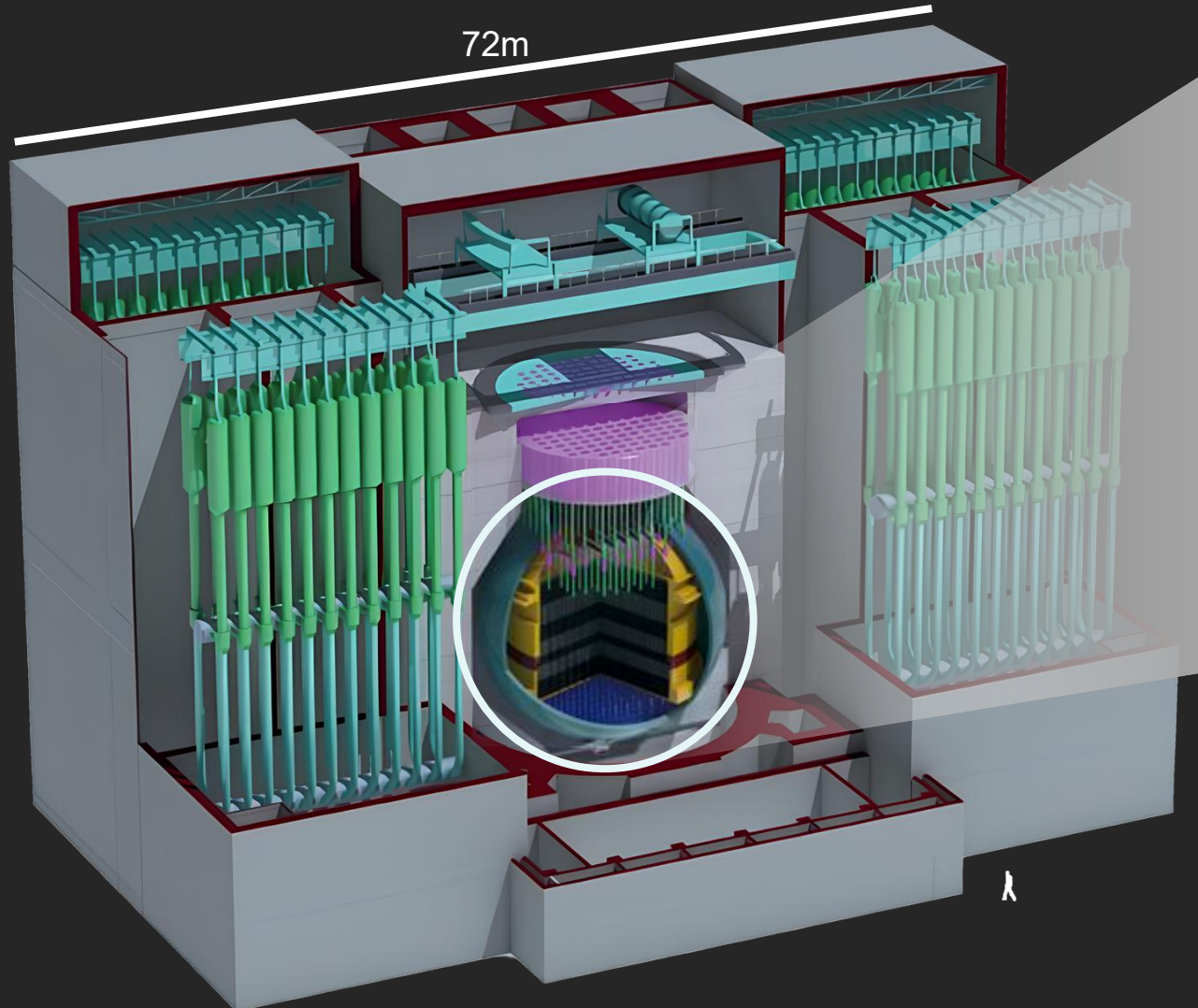
Prof. Fabrizio Campi
Advisor



Prof. Marco E. Ricotti
Advisor

Graphite reactors have a decommissioning problem due to the presence of thousands radioactive graphite blocks

The first commercial reactor family and one of the most promising Gen IV tech

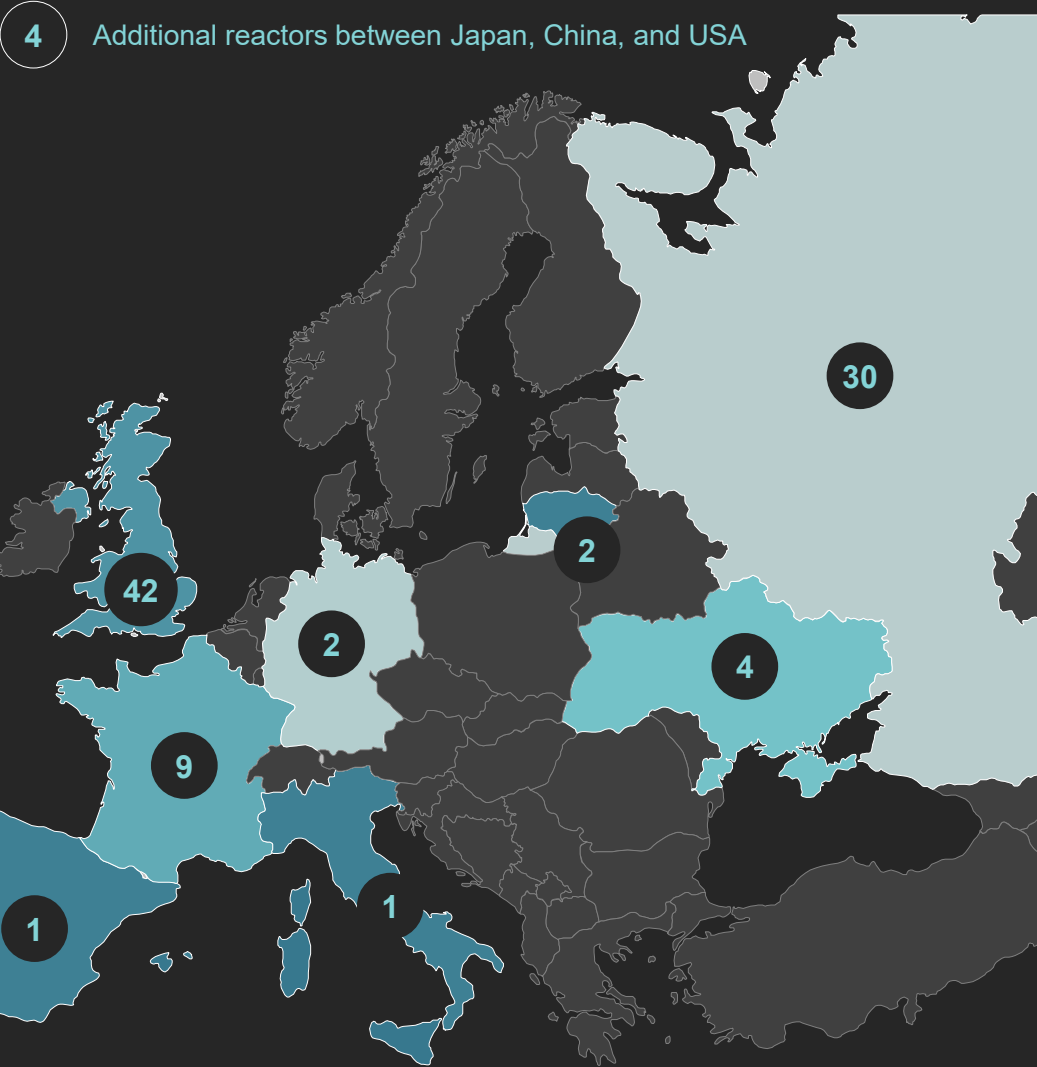


We estimate a total decommissioning budget of 142 B€ for Graphite reactors worldwide – mostly concentrated in EU

Worldwide graphite core reactor distribution and budget

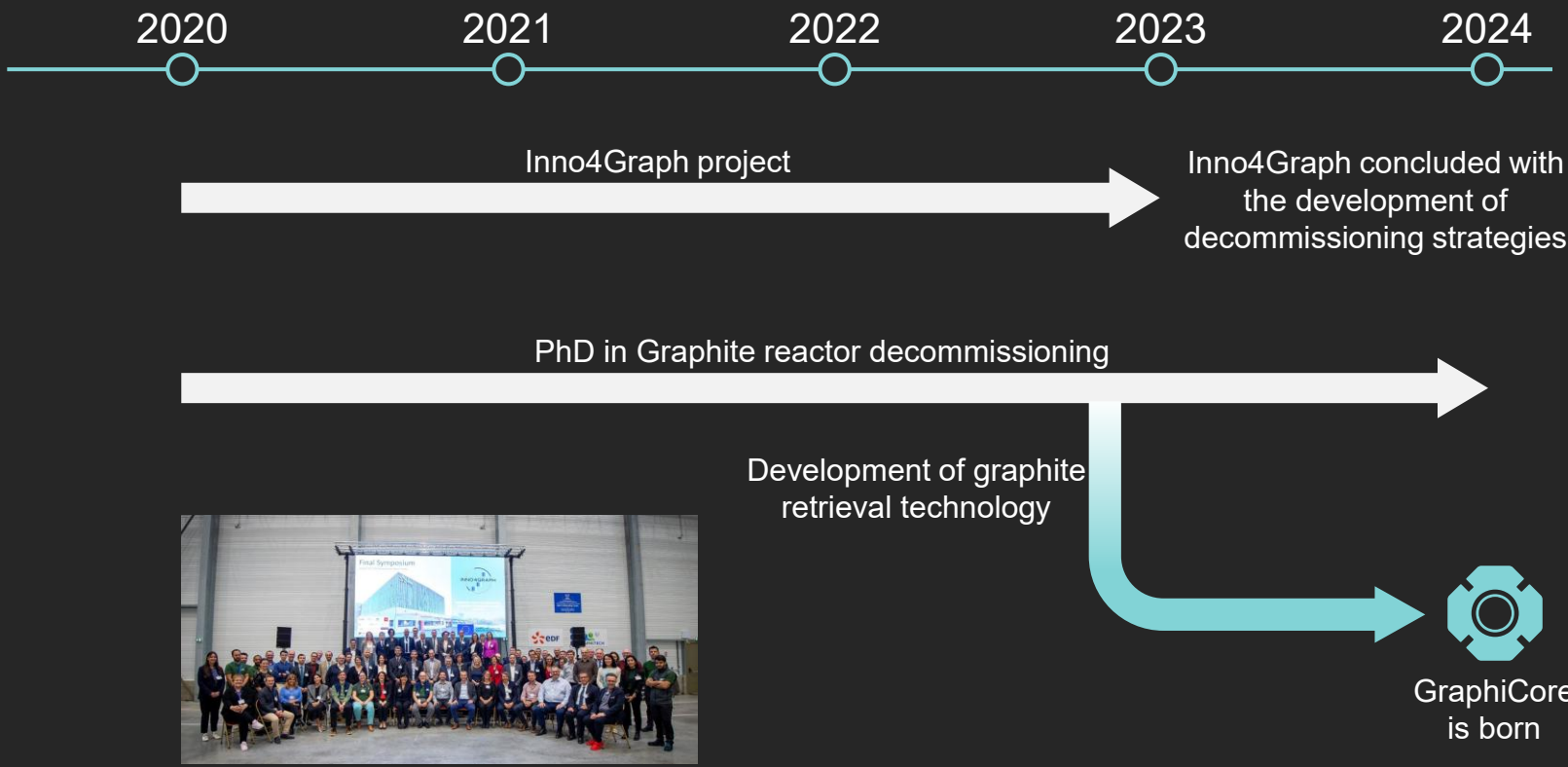
Country	# graphite reactors	Decommissioning Budget (€M)	GraphiCore Addressability
 Italy	1	800	
 Spain	1	3,900	
 Lithuania	2	3,300	
 UK	42	50,000	
 Japan	1	1,000	
 France	9	20,000	
 China	1	n.a.	
 Ukraine	4	30,000	
 Germany	2	2,500	
 USA	2	500	
 Russia	30	80,000	
 Total	95	142,000	

Low High



GraphiCore is born during Riccardo Chebac's Ph.D. in Inno4graph, a Horizon 2020 project on graphite dismantling

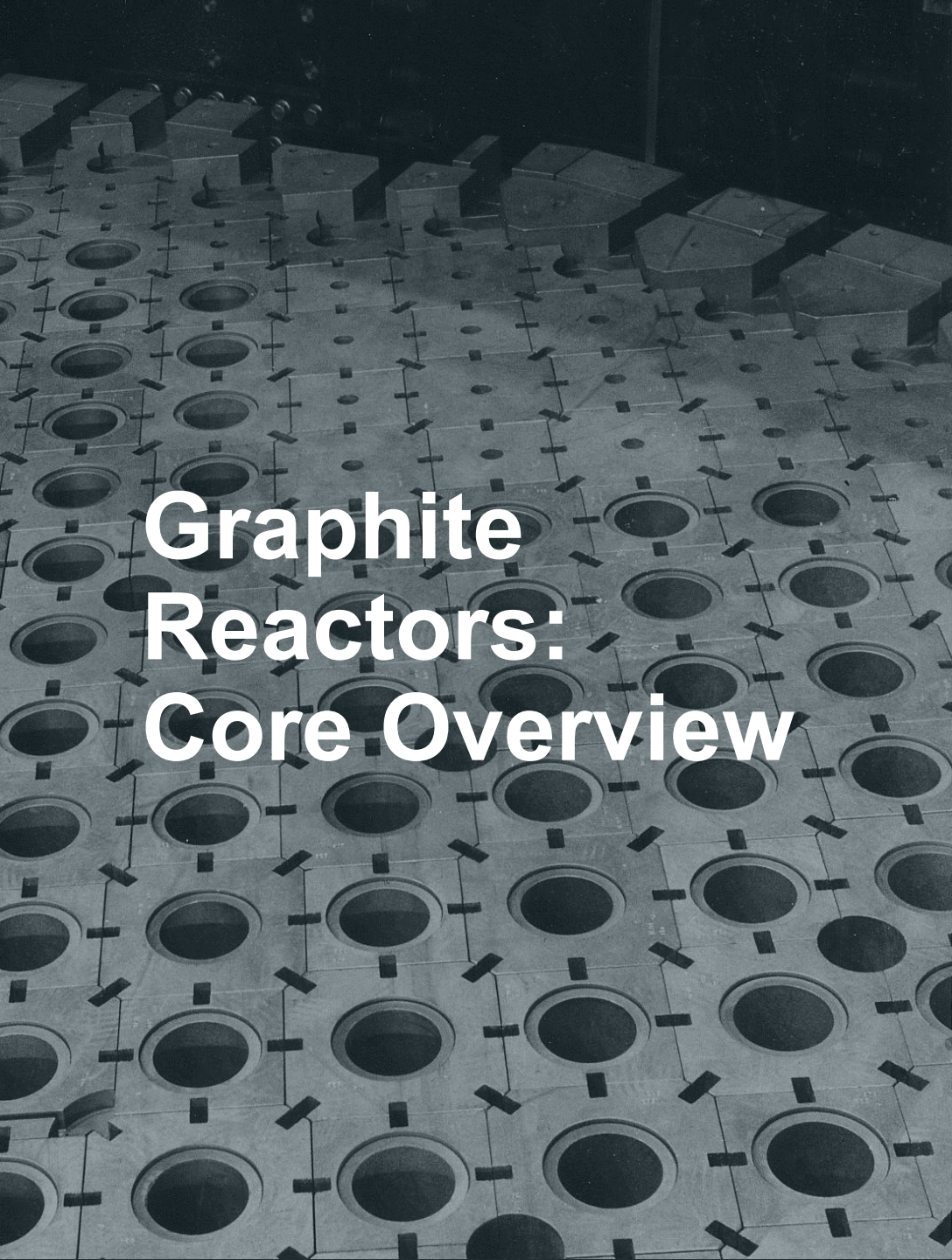
From this project, no adequate solution for Graphite blocks removal was developed



GraphiCore's Mandate

- 1 Address physical & mechanical constraints
- 2 Improving dismantling efficiency
- 3 Improving dismantling safety
- 4 Create an innovative technology to further develop as a startup





Graphite Reactors: Core Overview

100+

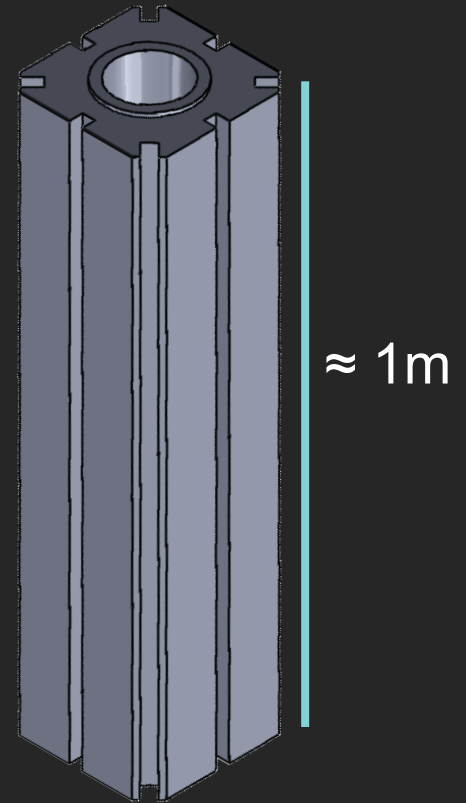
commercial and research
reactors use graphite

61

are in permanent
shutdown

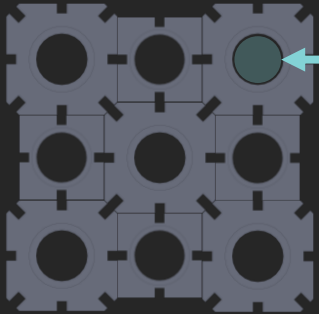
4

have been
dismantled

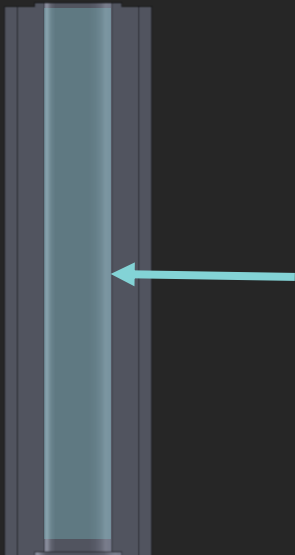


40-60 kg
~40000 blocks or
2000-3000 tons of
graphite per reactor

Currently, no industrial system can retrieve graphite blocks with the safety standards required



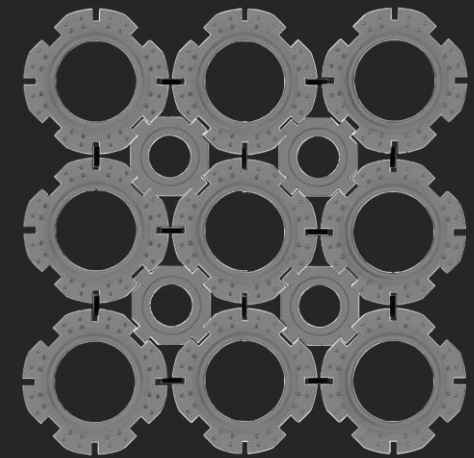
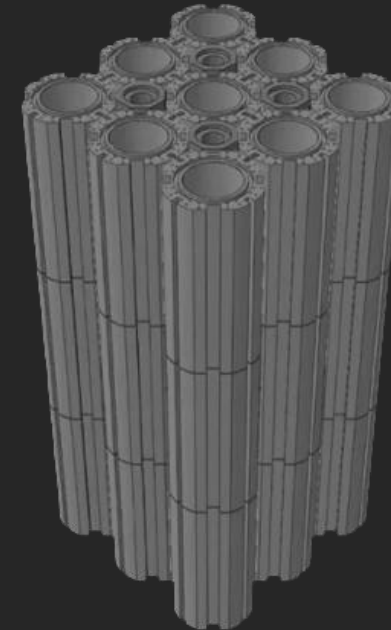
Graphite blocks have limited access points. The only available surface is the inner channel of the blocks used for fuel loading or coolant flow.



Problems arise when trying to grab the blocks from the inner surface since its slippery and fragile.

Radiation also causes dimensional changes, radiolytic oxidation and dust formation

Graphite necessitates the application of significant forces on the block for effective adhesion, increasing the risk of breakage through crack propagation.



We are developing a technology that can address the key issues in graphite reactor core dismantling

Key issues and drivers behind the development of GraphiCore grabbing unit



3D handling

Vertical and horizontal movement of graphite blocks



Wigner energy release

Temperature increase can lead to the release of Wigner energy and associated fires



Dust propagation

Radioactive dust propagation can pose a risk for future intervention and waste management



Highly radioactive environment

The center of the graphite core can reach radioactivity levels of 1Sv/h and any technological solution needs to safely operate in such environment



Broken / cracked blocks

Physical damage to blocks can make retrieval complicated



Geometrical constraints and difficult accessibility

Core access is limited from the top, and blocks can only slide on the vertical direction

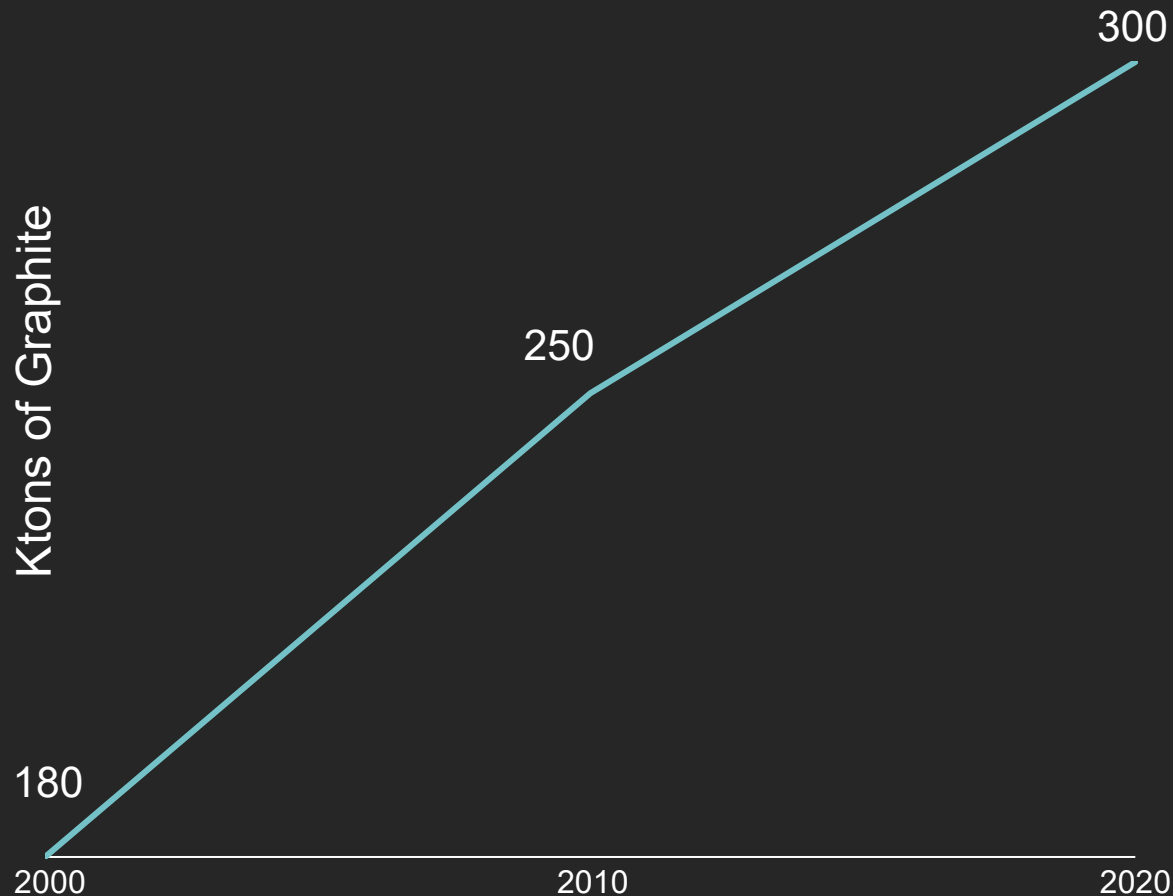


Huge amounts of blocks to be removed

Reactors can reach up to 40k blocks, and over 3000 tons

Irradiated graphite stockpile is accumulating and is still an unresolved issue

With more reactors entering shutdown, 300 ktons of graphite will be only the start



Total Graphite in need of retrieval and disposal

300,000 tons

More than 40 graphite-moderated reactors
will shut down by 2040

Previous attempts to lift graphite bricks have either failed or were not satisfactory

Whole block removal is currently the strategy most countries are approaching



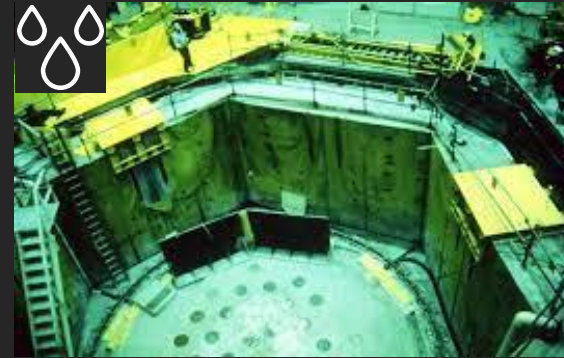
Hydraulic Splitter

- Given the fragile nature of graphite, the friction coefficient is extremely low
- These systems need to impart too much force on the blocks, thus risking to break them



Drill & Tap

- Used on the Windscale AGR as a POC of a possible decommissioning scenario
- This may be part of the solution for non-hollow graphite bricks within the reactor core



Underwater

- The solution creates enormous amounts of liquid radioactive waste that needs to be treated.
- Moreover, the operations were more complicated than expected

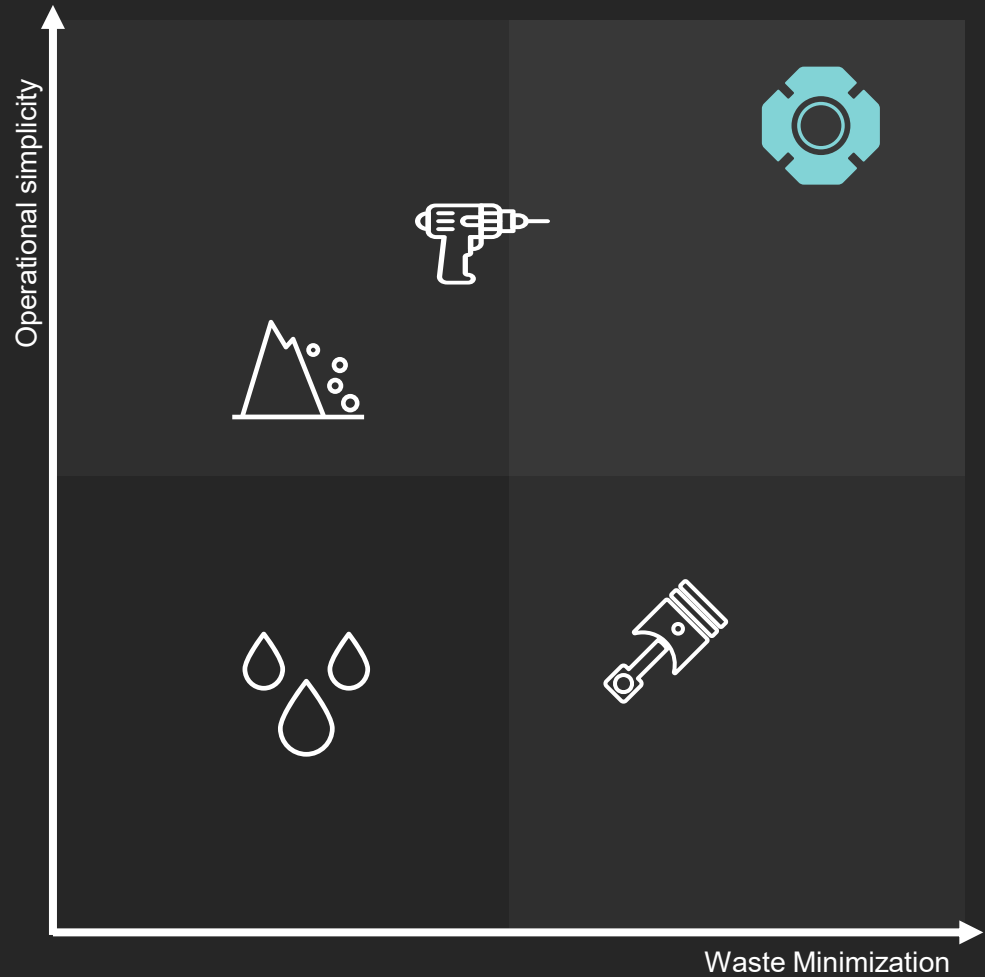


Remote Excavator

- Fastest solution
- Requires complex and expensive air treatment as well as a conditioning plant for the secondary radioactive waste produced

GraphiCore's design can outperform all graphite retrieval technologies tested since 1992

Attempted graphite removal technologies



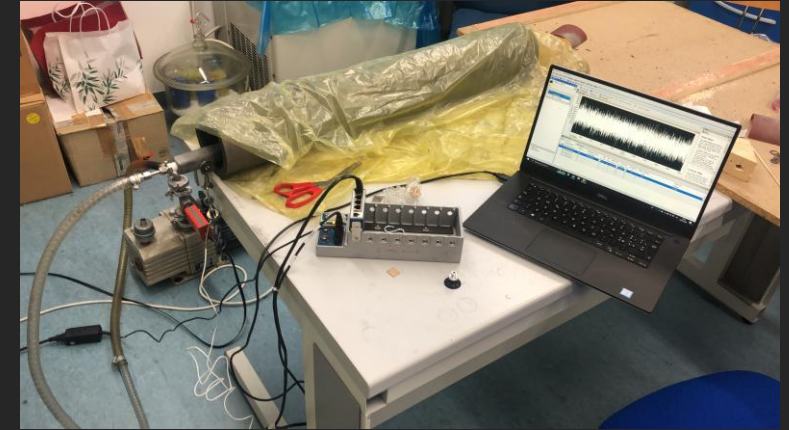
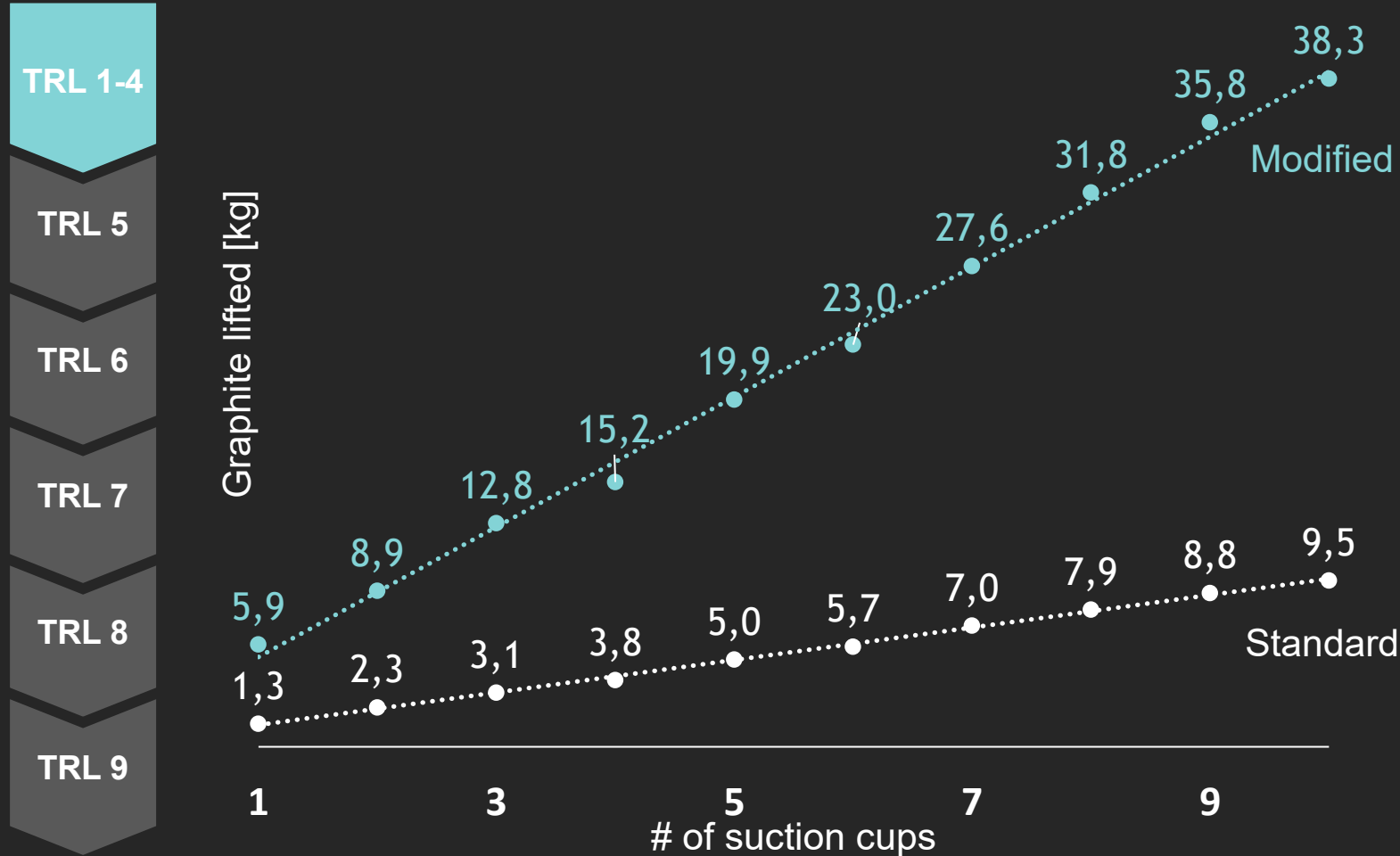
					
Safety					
Cost savings					
Speed					

Low  High 

GraphiCore's grabbing unit demonstrates superior safety, economic efficiency, and technical performance, making it the most advanced and reliable solution on the market

TRL 1-4 lab tests on advanced suction cup design increased lifting capability by 4x

Early design testing with advanced suction cups



Higher friction coefficient than regular suction cup increased lifting capability

Weight is distributed onto the metal body, increasing structural integrity

No dust is produced, increasing safety and reusability

TRL 5 design was able to lift graphite blocks safely using vacuum technology with low risk of grip failure

Early design testing with advanced suction cups

TRL 1-4

TRL 5

TRL 6

TRL 7

TRL 8

TRL 9

Early system design

Arrays of proprietary vacuum-actuated systems



Graphite test block



- 105 mm internal diameter (Latina NPP)
- 860 mm height
- 1.65 g / cm³ density
- ~20% porosity

Testing campaign

Dry - no coating	Wet - graphite with DeconPeel 5000 coating
Damaged graphite	Pristine graphite

X
2 pumps to evaluate flow rate sensitivity

D.V.P pump [4 m ³ /h]
R.A.T pump [16.8 m ³ /h]

TRL 5 design achieved safety factor of 3 in early testing by lifting 175.5 kg of graphite

TRL 5 design test results

TRL 1-4

TRL 5

TRL 6

TRL 7

TRL 8

TRL 9



TRL 6 design achieved a safety factor of >6 and can lift broken and scratched graphite blocks

TRL 6 design test results

TRL 1-4

TRL 5

TRL 6

TRL 7

TRL 8

TRL 9



- Compact modular design
- Independent vacuum for each arm
- Capable of lifting and handling **72.3 kg** of graphite in all directions using 1/5 of the brick length
- Self-adjusting suction cups
- Passive expansion of safety arms
- Can lift damaged or broken blocks
- Minimal graphite damage
- No dust production



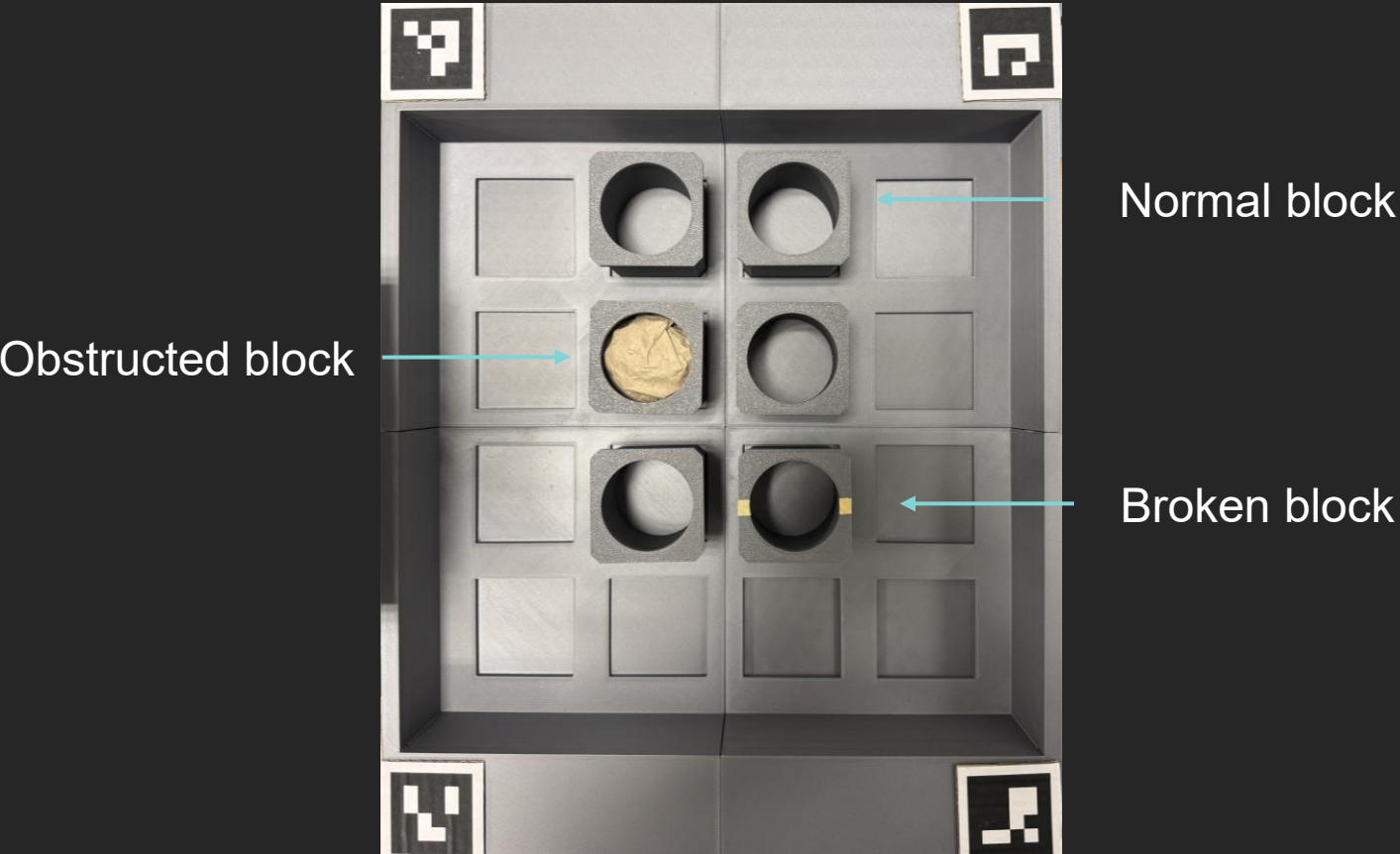
The technology encompasses all features required to safely handle and retrieve irradiated graphite blocks



GraphiCore demonstrated the capability of autonomous decision-making of graphite bricks removal in

Automation test results

- TRL 1-4
- TRL 5
- TRL 6
- TRL 7
- TRL 8
- TRL 9



To achieve TRL 7, we are partnering with an industry leader to test the technology on a graphite core mock-up

TRL 7 test design

TRL 1-4

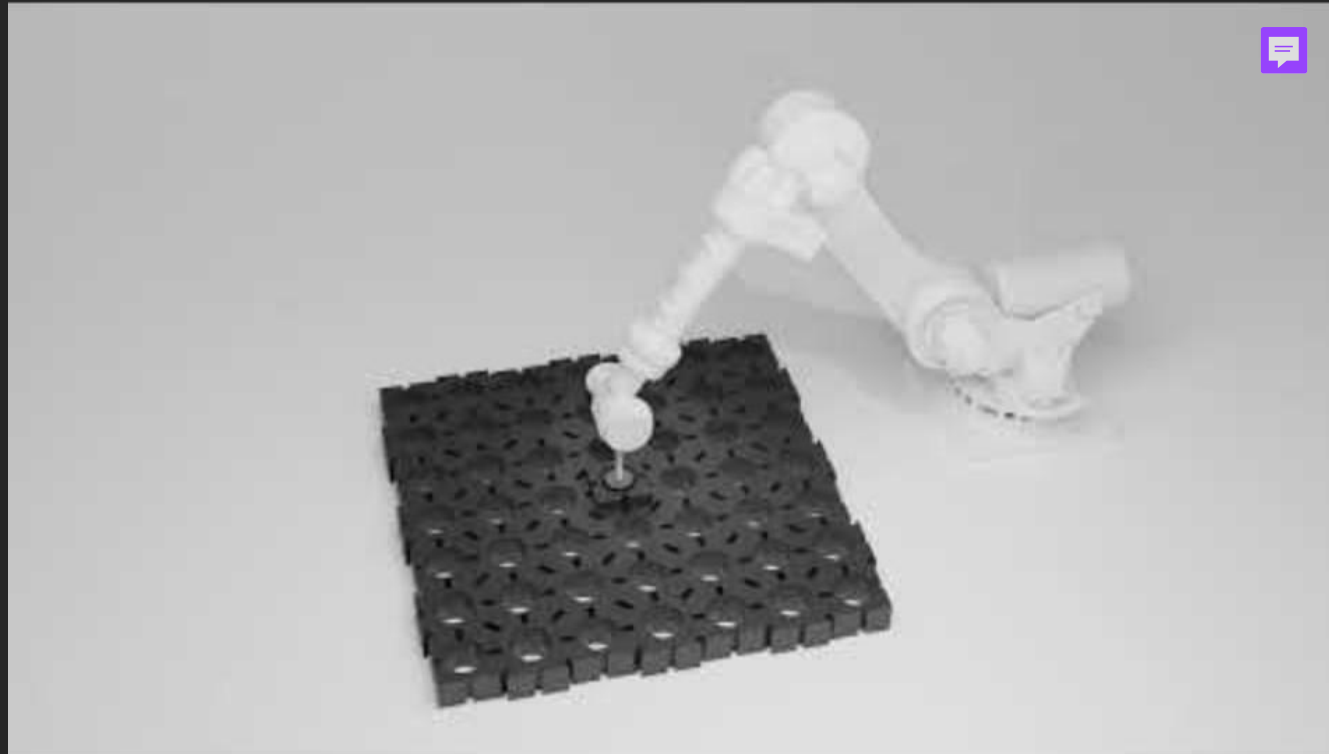
TRL 5

TRL 6

TRL 7

TRL 8

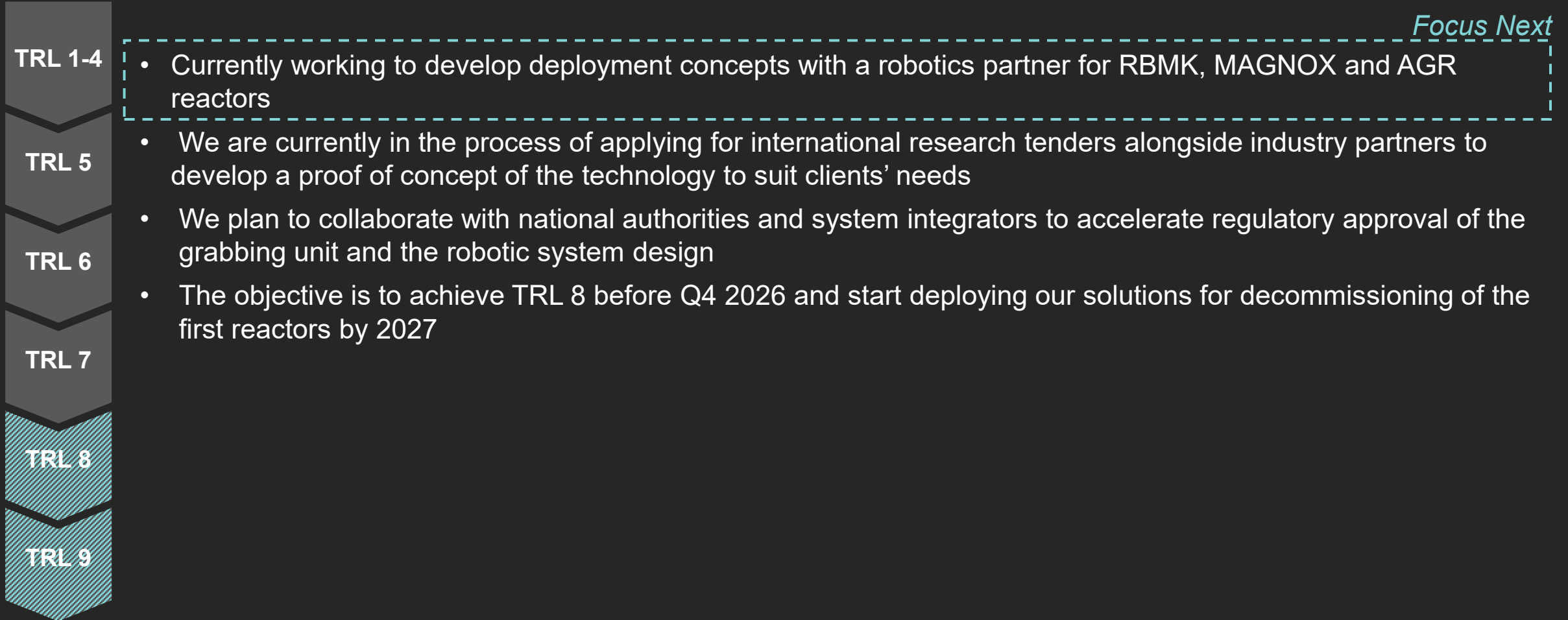
TRL 9



- Non-radioactive testing in Latina NPP (Magnox)
- The grabbing unit will be attached to an overhead crane
- Test planned for end of [Q3-4 2025](#)
- The result will validate the applicability of our technology in a real environment

To achieve TRL 8 and 9 we plan to enter decommissioning projects as technology provider

Plan to reach TRL 8-9

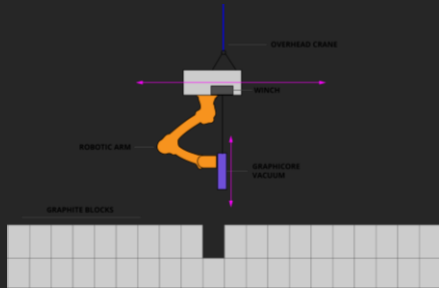


For example, we are developing two proof of concepts with Createc and Sogin

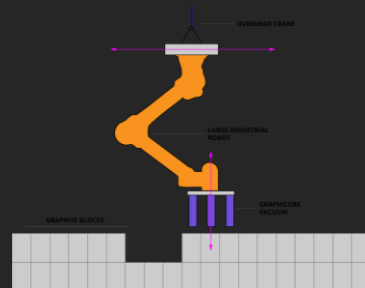
Overview of GraphiCore collaborations

Concepts under development with Createc

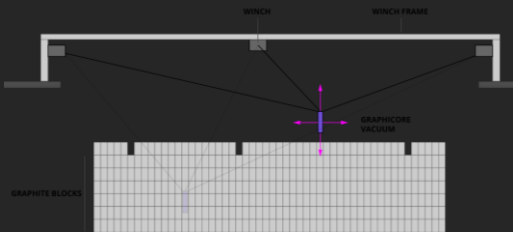
Small robot & overhead crane



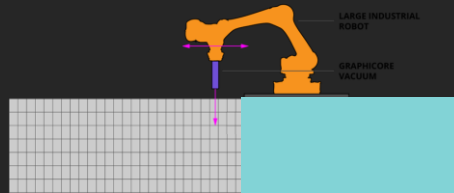
Large Robot & Overhead crane



Cable-driven removal



Large robot on robotic arm



The concepts are currently being discussed alongside a potential PoC partner in the UK (Trawsfynydd reactor)

Demonstrator with Sogin @Latina NPP

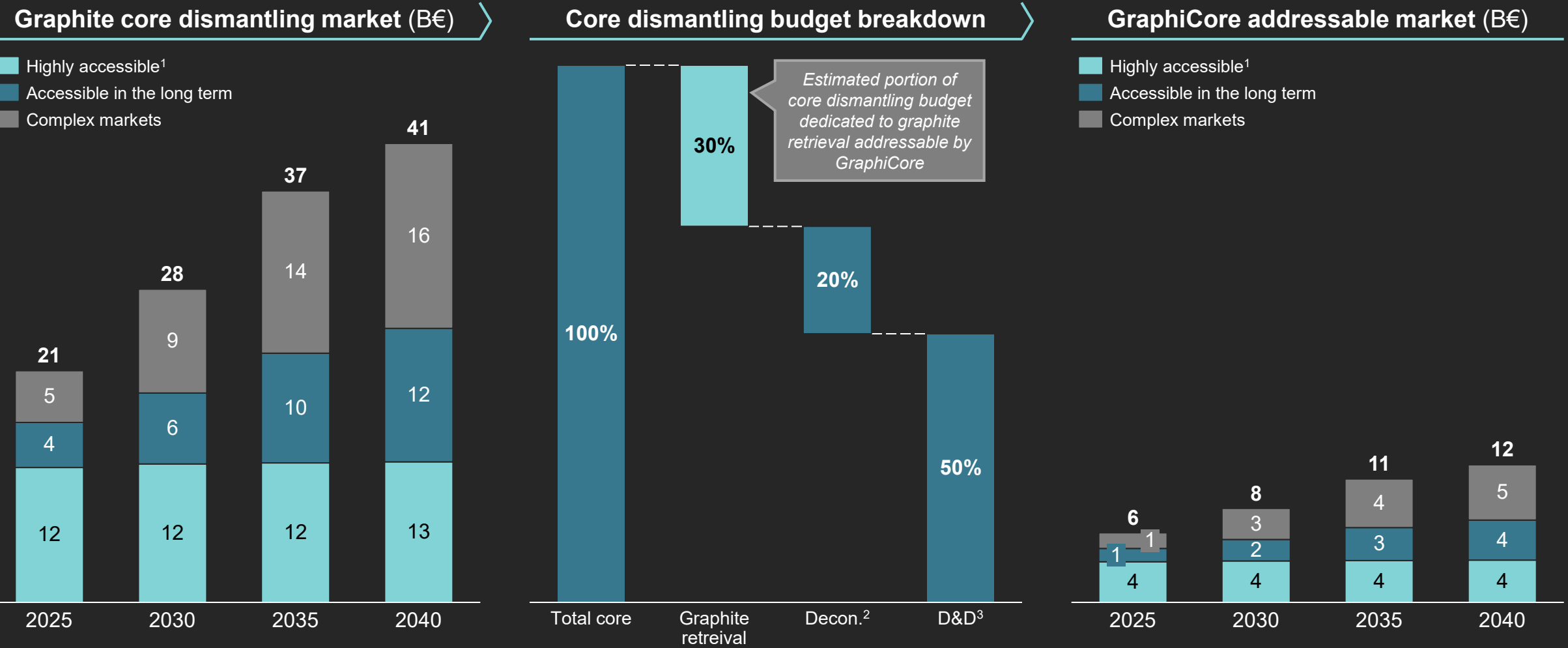


Key objectives

- Demonstrate technology's performance in Magnox reactor blocks
- Testing and demonstration in a real environment
- Showcasing technical feasibility of decommissioning of Latina NPP

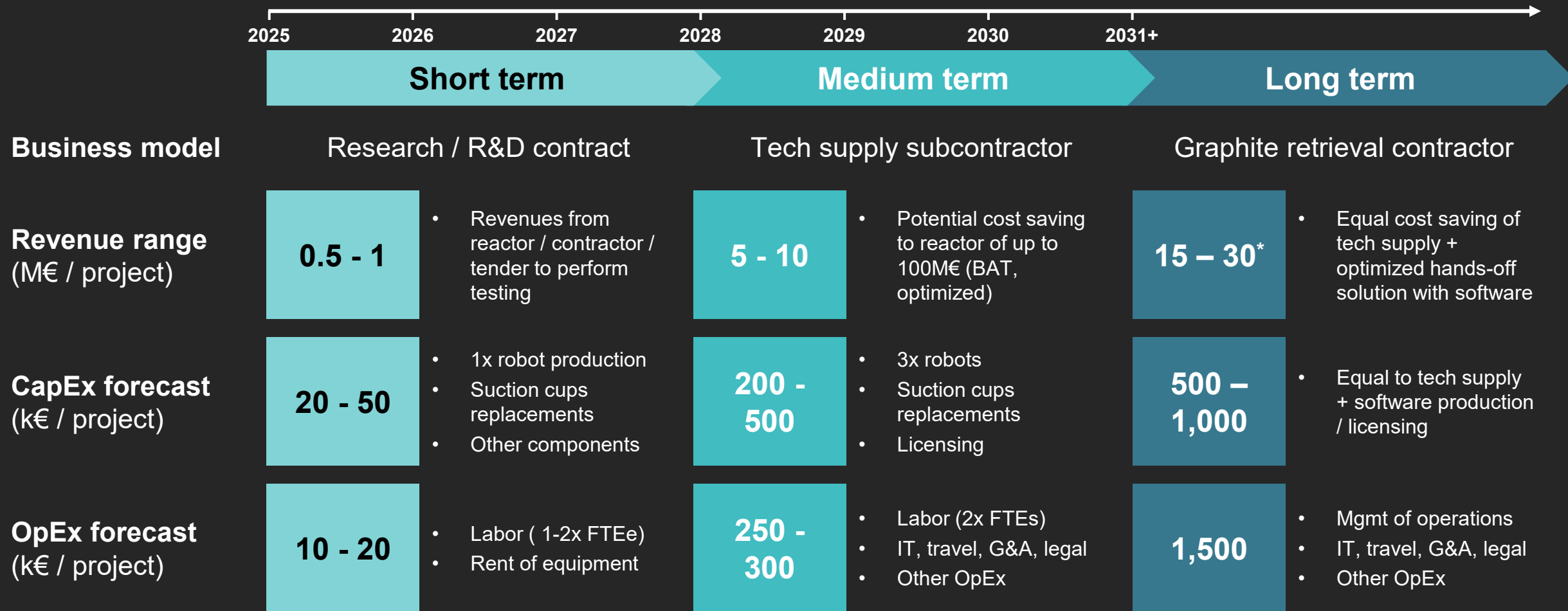
GraphiCore can address 4 B€ market based on an estimate of graphite retrieval budgets

Overview of GraphiCore market size estimate



We plan to enter the market with 3 business models, research contract will provide early validations

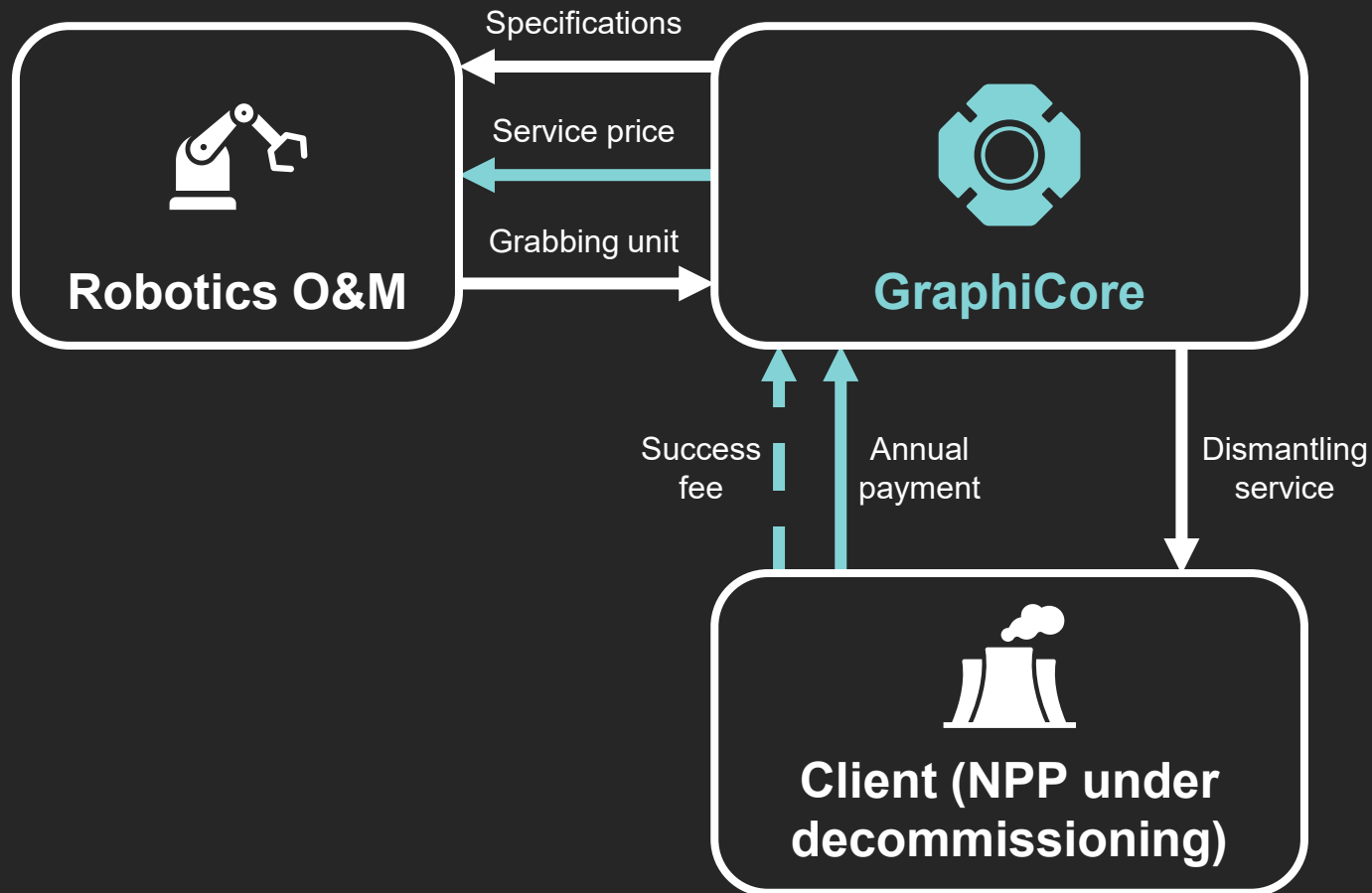
Overview of GraphiCore business model development



*Note: This represents ~15% of the estimated addressable budget per reactor

GraphiCore will provide a graphite block removal service in exchange of a remuneration based on performance

Overview of GraphiCore's business model



Comments

- GraphiCore will outsource the production of the grabbing unit to a European robotics manufacturer
- The dismantling services will take place in two waves:
 - One initial R&D phase to prepare operations for core dismantling, where the grabbing unit will be adapted to the client's robotic arm, alongside testing, calibrations, and research
 - 5 years dismantling operation of the graphite reactor core
- All waste management will be handled by the client, including irradiated graphite blocks and grabbing unit

Prospective Clients / Partners

Decommissioning
Gen I & 2



Robotics for decom



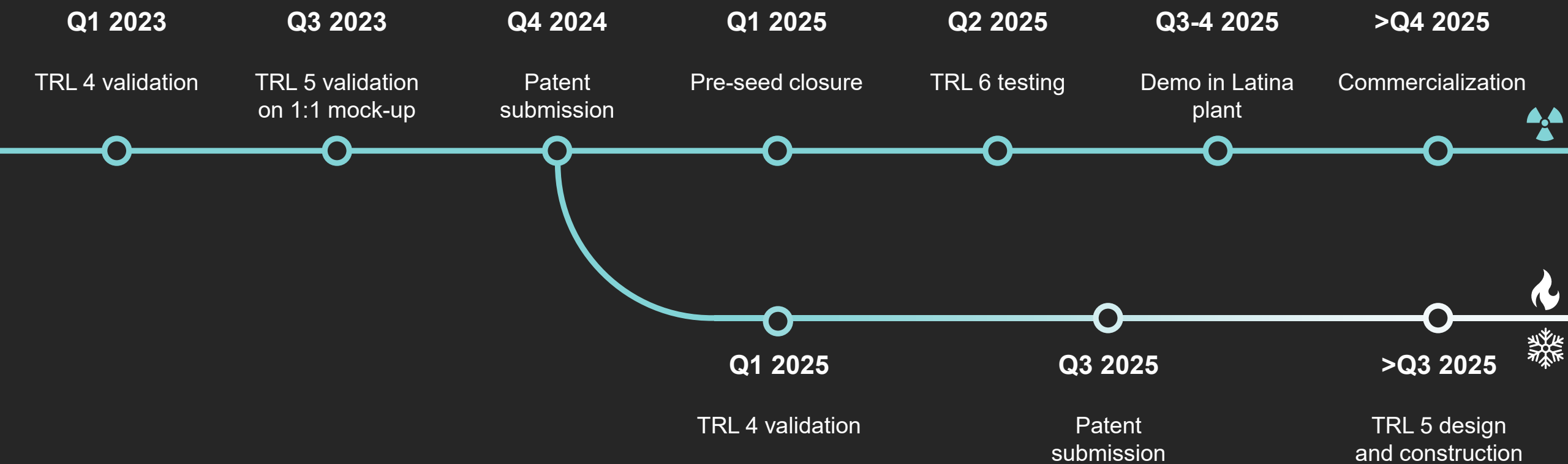
Possible business upside

Gen IV & Front
End



Since 2024, we achieved TRL 6 for the nuclear end-effector and began development for a high-temperature prototype

Overview of GraphiCore technological timeline and milestones



Early handler prototypes can lift steel continuously from -200°C to 1,200°C, peak resistance at ~1,700 °C

Results achieved

- Developed a suction system capable of operating at temperatures ranging from -200°C to 1200°C
- Maximum lifting capacity to date: 2.6 kg of steel at 1200°C for an annular suction cup of 24-27mm diameter
- Normalized lifting capability: 2.16 kg/cm²
- 2 suction cups and 1 soft mechanical gripper and 1 pneumatic gripper tube design are being considered potential for industrialization and patenting



We envision three different high-temperature material handling systems, two of which based on vacuum tech

Overview of high-temperature handling devices under development

Proposed system		Pros / Cons	KPIs to test
Vacuum-based system	Traditional suction cup	✓ High grip ✓ Ideal for repeatable geometries ✗ Poor seal on rough or porous surfaces	• Max grip force • Failure rate after 500+ hot cycles • Material degradation (dose tolerance)
	Sponge suction	✓ Adapts to rough/uneven surfaces ✓ Softer contact reduces cracking risk ✗ Lower grip strength	• Grip on rough surfaces • Cycle life in dusty, hot environments • Deformation after thermal + radiation load
Mechanical handler	Soft adaptable tweezers	✓ Highest payload potential ✓ Conforms to complex shapes ✓ Gentle on fragile materials ✗ Not suitable for flat geometries	• Grip adaptability on irregular shapes • Surface damage after repeated use • Thermal resistance of tips

Patent Portfolio

- ITALIA 102023000026157: *“Dispositivo di aggancio di blocchi di grafite disposti in reattori nucleari, ed apparato e metodo per l'estrazione di tali blocchi di grafite”* → Confirmed
- PCT/EP2024/084850: *“Grabbing device of graphite blocks arranged in nuclear reactors, and apparatus and method for extracting such graphite blocks”* → Pending

Awards

- EURATOM Nuclear Innovation Prize in Radioactive Waste Management 2025
- Unicredit Startlab Impact & Innovation
- Italian Nuclear Ph.D. Award 2025 (related to CEO's Ph.D. where GC's tech was developed)
- Sustainable Nuclear Energy Technology Platform (SNETP) Innovation Prize 2024
- Hello Tomorrow Deep tech Pioneer (top 10 early-stage startup out of 4600+ worldwide)
- Winner Switch2Product 2023



THANK YOU | www.graphicore.eu

Contact: riccardo.chebac@graphicore.eu

