

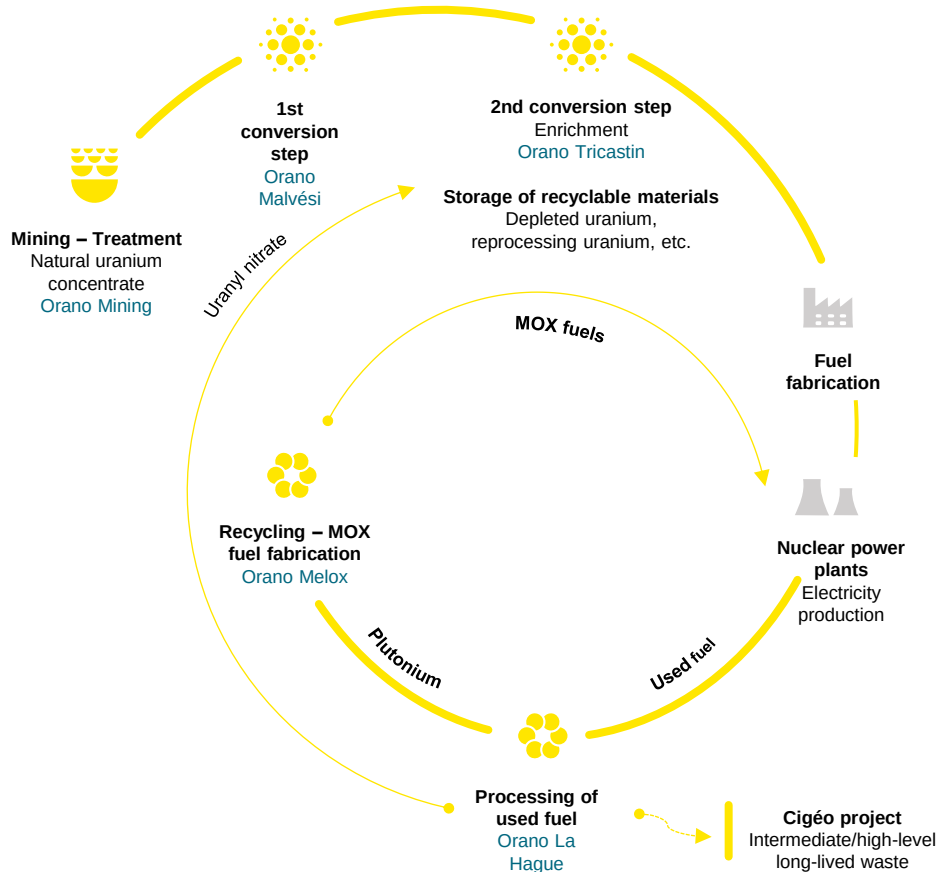
HALEU

Amir Vexler
CEO, Orano USA

National Academy of Sciences
September 15, 2021



Orano: Ensuring excellence across the entire fuel cycle ...



Orano supplies customers throughout the global commercial nuclear market, offering products and services across the nuclear fuel cycle – from mining to decommissioning.

Orano is also pursuing nuclear medicine applications through its Orano Med subsidiary, developing targeted alpha therapies for hard-to-treat cancers using Lead-212 processed from mining waste.



Nuclear Packages & Services



Engineering



Decommissioning & Services

— A global leader in the nuclear energy industry

Orano key facts and figures

€ 3.7 bn

Revenue

€ 27 bn

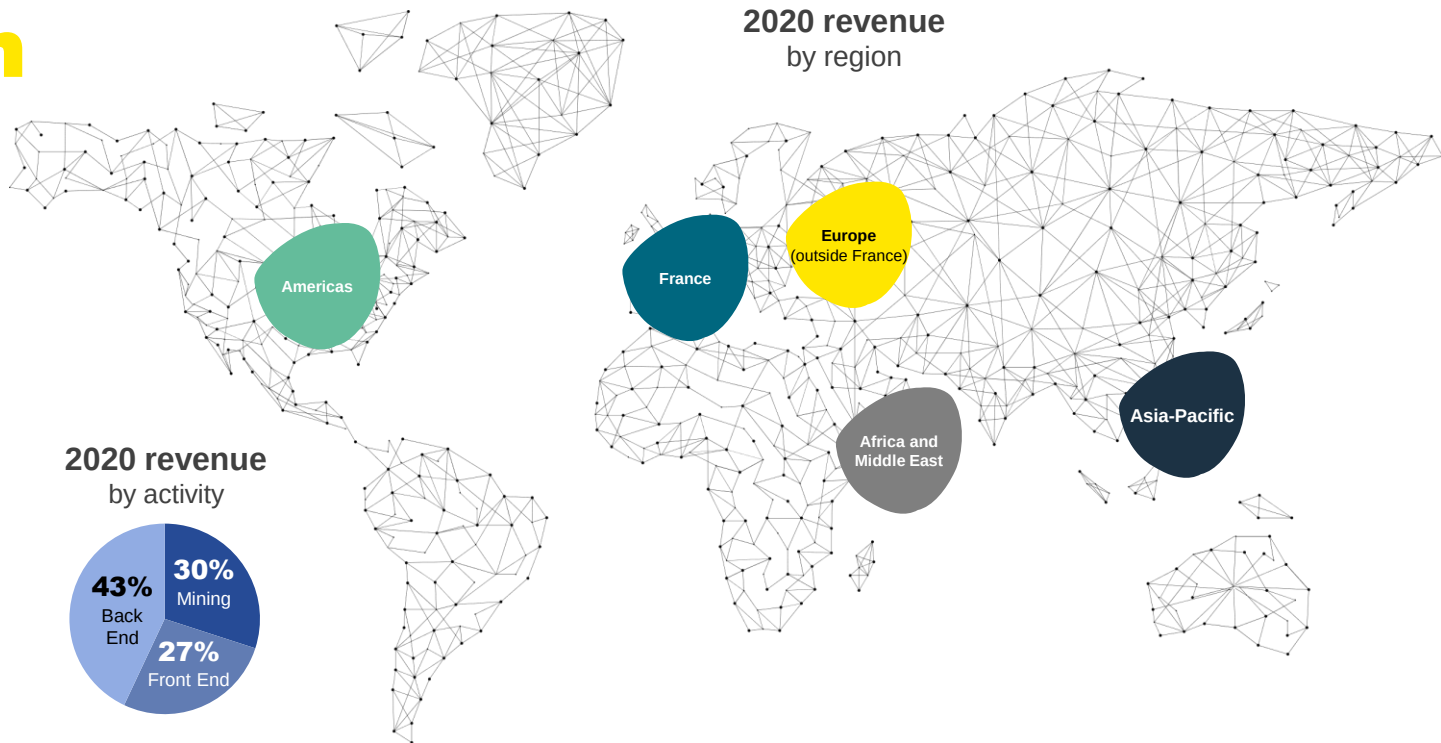
Order backlog
= 7+ years of revenue)

Top 3

in the world
in its key activities

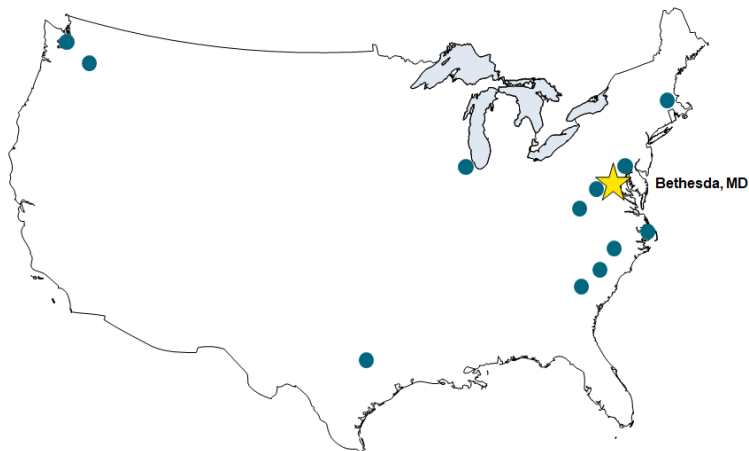
16,500

Employees



Orano USA

- Front End Sales
- Orano Federal Services
- Orano Med
- Orano TN
- Orano Decommissioning Services



The Nuclear Packages & Services Business Unit

An international player in nuclear logistics with an ambitious growth target and unique expertise

With more than 60 years experience, Orano provides global logistics solutions to its customers throughout the world, ranging from the design and approval of packages to the transport of nuclear materials.

Orano conducts more than 5,000 shipments around the world each year, in compliance with the most stringent international safety and security requirements.

Orano's unique expertise in nuclear logistics services encompasses engineering, licensing, packaging, transport and storage solutions for nuclear materials.

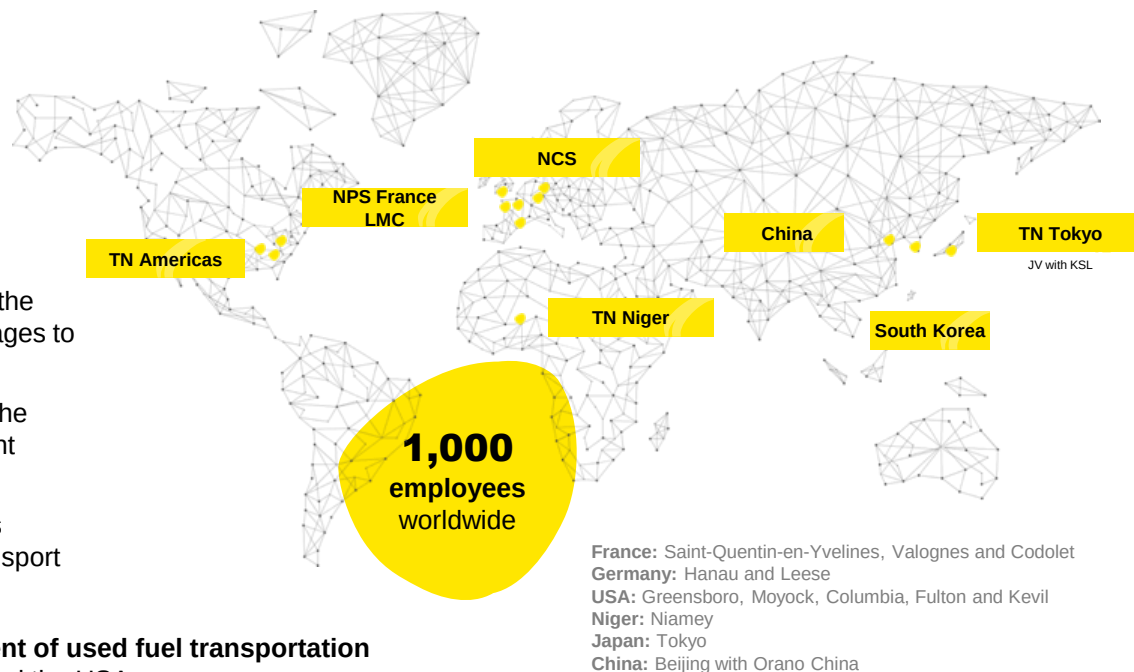
Global leader
in nuclear transport

Global leader
in used fuel dry storage

Development of used fuel transportation
in Europe and the USA

Growth in business related to waste management
from decommissioning nuclear reactors

Diversification of activities in the front end of the
fuel cycle and into certain non-nuclear areas



Chemistry & Enrichment

From the Malvési (Aude) and Tricastin (Drôme/Vaucluse) sites, Orano operates on an industrial platform which sets the standard for the front end of the cycle, deploying its expertise acquired from more than 60 years' experience in the conversion of uranium and the chemistry of fluorine.

- **Georges Besse II (enrichment; 2011):** Nominal capacity of 7.5 MSWUs reached in 2016; the most efficient technology worldwide
- **Philippe Costes (conversion; 2016 & 2018)**
Nominal capacity of 15,000 tons of UF₆ ; the only conversion industry with innovative processes
- **Other activities**
Defluorination and denitration plants, maintenance activity of our cylinders for our customers

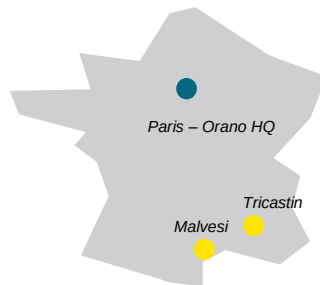
Our customers' security of supply is guaranteed by fully modernized conversion and enrichment plants meeting the highest standards of safety and security with a reduced environmental footprint.

27%
of Orano's
revenue

7.5 million
SWUs
per year for enrichment

1,900
employees

15,000
metric tons
of installed capacity in
conversion per year



Our strengths

- About **one hundred customers** worldwide
- A **strong** order backlog
- 1st industry player in the world to have **modernized** its conversion production tools
- **Security of supply** for its customers over the long term thanks to a modernized industrial platform
- An 80% reduction in GHG emissions and 96% lower electricity consumption since 2004

Tricastin-Malvési Platform

An expert in uranium transformation, purification, enrichment & fluorine chemistry

55+ years
experience & expertise

~ \$1 Bn/yr
~ $\frac{1}{4}$ of Orano
sales revenue

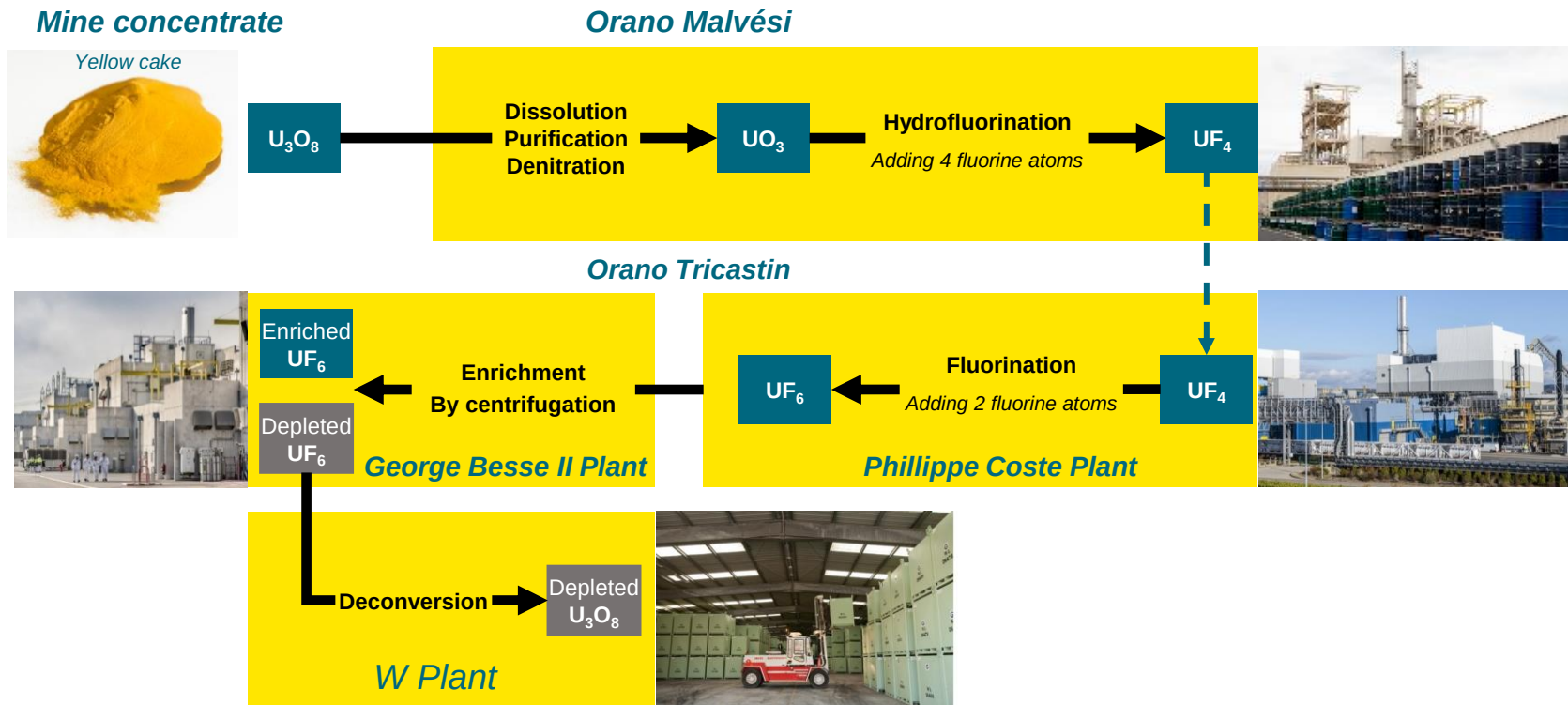
10 years
Order book



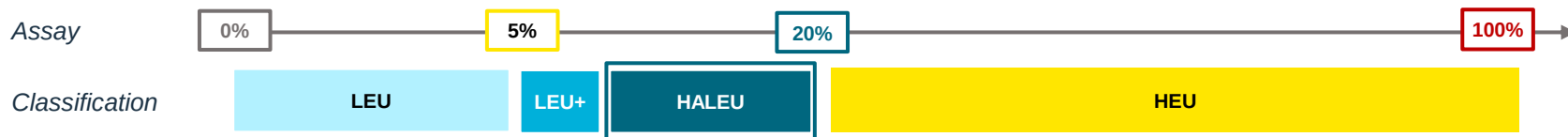
more than
60 Customers
40 Partnerships

Tricastin- Malvési platform

An expert in uranium transformation, purification, enrichment & fluorine chemistry



HALEU Background & Context



HALEU: Current source of supply?

To date, HALEU is mostly used in Research and Test Reactors (RTRs) and procured in metal form for the fuel fabrication process.

In Western countries, HALEU metal is supplied by:

- Down-blending HEU declassified from U.S. military stockpiles
- Direct natural uranium enrichment and metallization from Russian available industrial capacities

=> No western production capacities

U.S. Department of Energy (DOE) announced that the stock of HEU available for domestic and foreign use will be exhausted by 2035-2040, leaving Russia as the only supplier of HALEU.

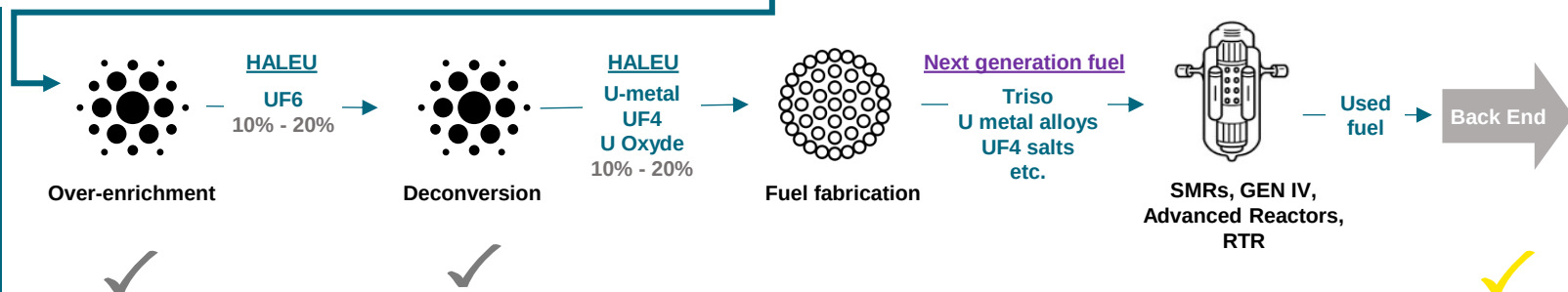
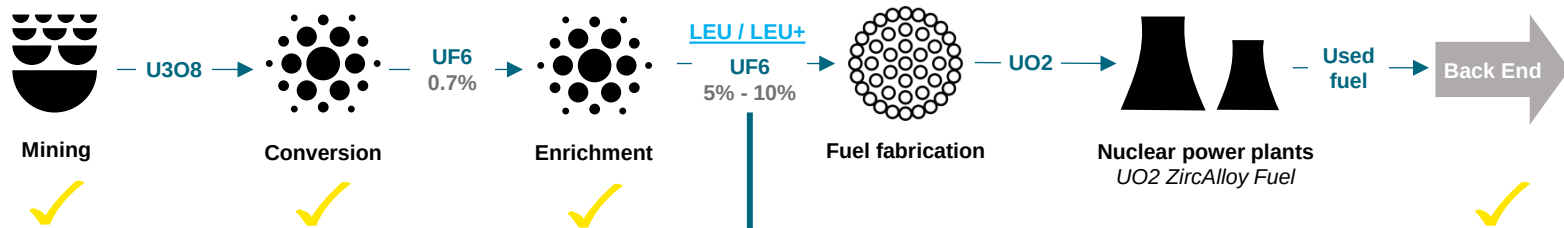
=> Current supply chain is not sustainable



Given emerging demand for higher enrichment levels, production beyond current 5% enrichment is being evaluated

→ Defining a sustainable source of HALEU supply is becoming crucial for the development of numerous projects

Impact on front-end supply chain & Orano capabilities



HALEU - A promising market

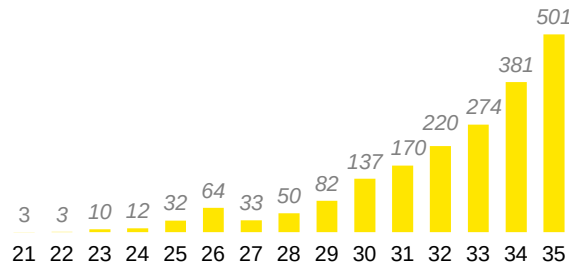
Market
Players
Assay
Chemical form

Commercial
Advanced reactors / fuel concept
~5%-19,75%
UF6, Oxyde, metal, salt

Research
Research and Test Reactors
~5%-19,75%
metal

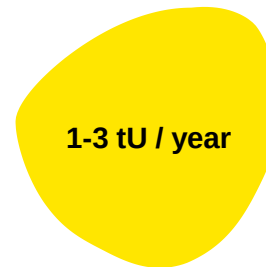
Estimated Demand Forecast
Nuclear Energy Institute

Estimated annual requirements for HALEU to 2035 (tU/year)



⇒ **Promising, but uncertain, demand driven by new concepts of advanced reactors / fuel and SMRs, mainly in North America**

- The various chemical forms requested represent a technological challenge
- The expected initial needs for 2028-30 appears ambitious
- Question marks around the concepts that will emerge



⇒ **Modest but certain demand**

- Although RTRs were historically using metal HEU, most of them have recently been transitioning to 19.75% HALEU metal fuel
- Hence, ensuring the availability and durability of metal HALEU supply is becoming critical to protect domestic and international interests of western countries

Potential requirement vs. impact on front-end markets

Order of magnitude

World nameplate capacity

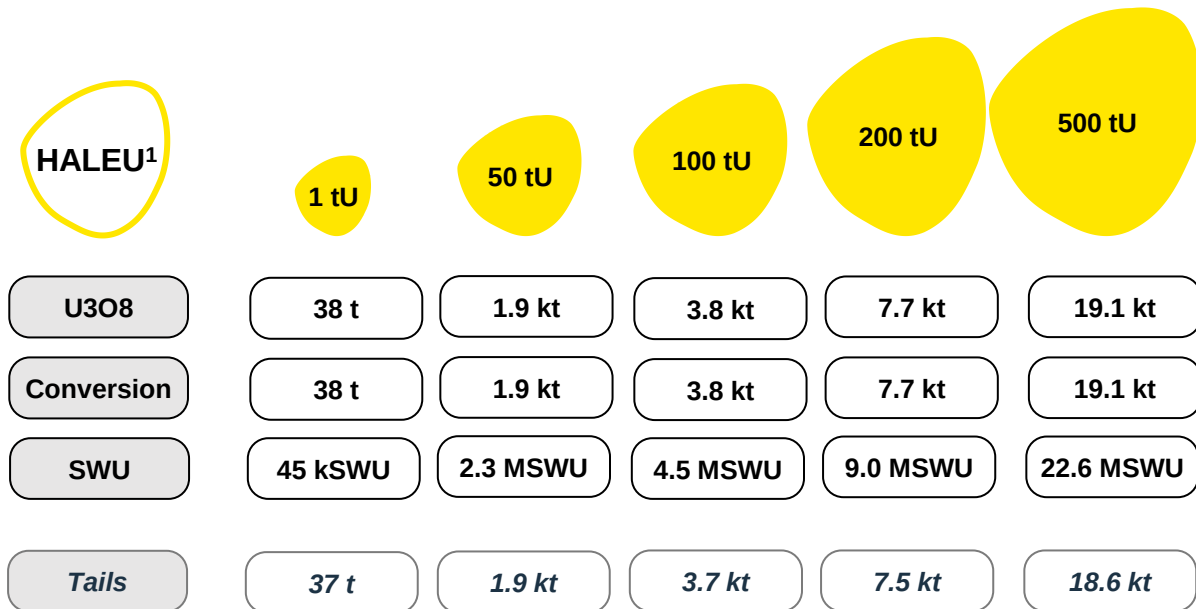
Figure 6.4: Location of conversion and enrichment facilities and their estimated production capacity in 2020



U308	70 kt
Conversion	62 kt
SWU	60 MSWU

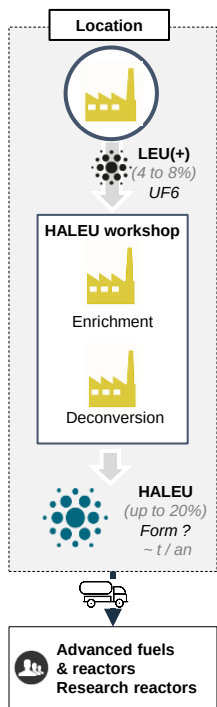
Source: WNA

Underlying annual requirements for HALEU given quantities



Note (1): Np: 19.75% - Nf: 0.711% - Nt: 0.2%

Challenges: Completing the future nuclear fuel chain supply



Although securing the availability of HALEU appears critical, it is also a challenge

→ Raising fuel enrichment above 5% ^{235}U will directly impact many of the established fuel cycle steps and sub-steps, requiring infrastructure and logistics upgrades together with international regulation evolution

HALEU facility: Key Requirements

Technology and Industrial

- Enrichment: A state-of-the-art enrichment technology for a highly competitive production
- De-conversion: industrial expertise and hands-on know-how to de-convert UF6 under the required chemical form
- Industrial & chemical know-how: expertise for an optimized operation
- Appropriate designed and built installations to account for the criticality of such assay level

Logistics

- An available transportation solution for HALEU:
 - Suitable for the requested chemical form
 - Compliant with the existing industrial facilities and international regulations

Regulatory

- Obtain appropriate regulatory approvals and authorizations

Economics

- Appropriate financing solutions to finance the various studies and construction works

HALEU Supply Concerns

Q41: What issues keep you up at night?

(multiple answers allowed)

Rank	Issue	Score	# of companies	2020
1	Availability of High Assay Low-Enriched Uranium	65%	11	#1
2	Ability to sell initial 10-20 commercial units (beyond initial demo unit)	53%	9	#2
3 ^{tie}	Current NRC reactor licensing process (other than Part 53)	47%	8	#7
3 ^{tie}	Sufficient government funding for the development of advanced reactor technologies	47%	8	#3
3 ^{tie}	Availability of financing for domestic deployment	47%	8	#4
6 ^{tie}	Administration change (in 4-8 years) to one that is not supportive of nuclear	29%	5	#5
6 ^{tie}	Availability of financing for international deployment	29%	5	#6
6 ^{tie}	Sufficient domestic manufacturing resources to produce your design	29%	5	
9	Potential requirements for safeguards and security	24%	4	
10	Part 53 (based on NRC current language)	18%	3	
	other Clear waste disposition policy, sufficient federal resources, etc.		---	
			17	



Orano: A Proven Industry Partner

Expertise + Access to Technology + Track Record of Delivery = Assured Supply

- Advanced nuclear power applications at commercial scale are essential to meeting U.S. and global industrial decarbonization goals
- Assured availability of HALEU is necessary for the commercialization of advanced reactors in the U.S. and throughout the world – there are no commercial HALEU producers outside Russia
- Orano is committed to fueling the future of nuclear energy through the development of commercial platforms that secure HALEU production capacity and the associated logistics infrastructure
- The initial diversity of OEM requirements requires a flexible platform for HALEU production – including integrated advanced chemistry applications backed by Orano's expertise and delivered through industrial partnership
- Orano is focused on U.S. demand signals and emergent DOE and commercial OEM requirements – pursuing greater clarity around commercial offtake commitments and the availability of policy tools that can accelerate investment in this critical infrastructure
- A commercially-committed, geopolitically stable supply chain will fuel expansion of advanced nuclear energy



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