STATE ATOMIC ENERGY CORPORATION “ROSATOM”

# HALEU: ROSATOM VIEW

**Fletcher Newton**

**President**
**TENEX-USA**

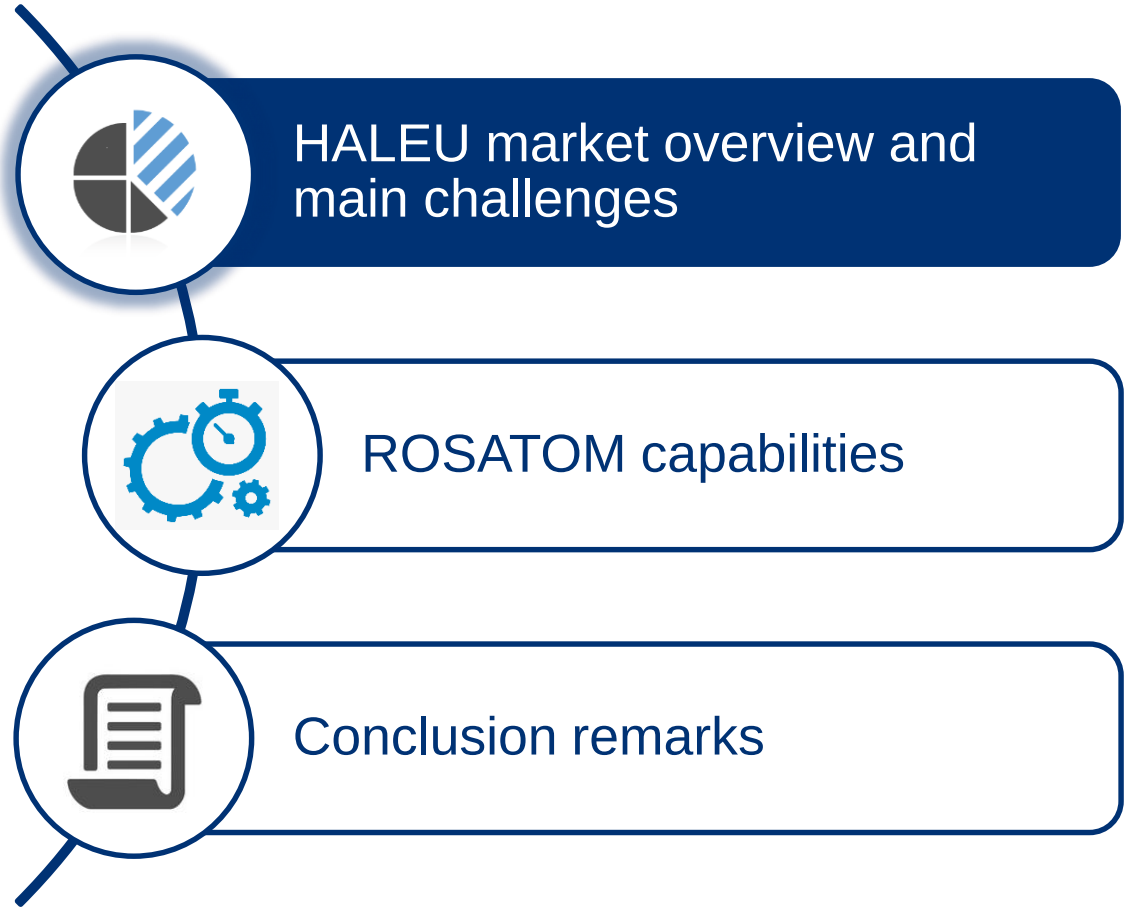
**Nadezhda Kolosovskaya**

**Senior Expert**
**for Business Development**
**TVEL**

GAIN-EPRI-NEI HALEU Webinar

April 28-29, 2020

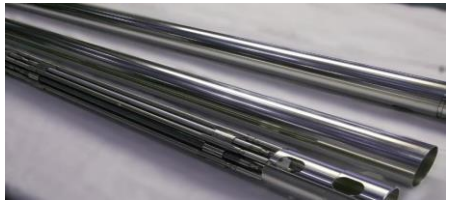
# PRESENTATION CONTENT



# HALEU MARKET SEGMENTS

High Assay Low Enriched Uranium (HALEU) is a product with U-235 assay higher than 5% and below 20% required potentially for such purposes as:

**Commercial LWRs applying advanced and optimized fuel solutions**



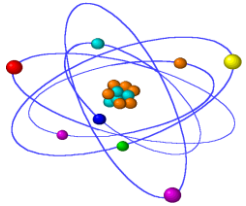
New market segment
U-235 content
5-7%

**Advanced new generation reactors (small modular reactors)**

New market segment
U-235 content
up to 19,75%

**Research & test reactors***

**Medical isotopes facilities***



Traditional market segments

**Market size (by 2030): US ~600 MTU (*NEI, 2018*), outside US ≤ 10MTU (*ESA, 2019*)**

**Common forms**

- metal
- oxide (U3O8, UO2)
- hexafluoride (UF6)

**Technological processes for HALEU production**

- natural UF6 enrichment (*license amendments required for Western enrichers*)
- HEU downblending (*limited HEU availability*)

HALEU market size in the next decade is expected to be relatively small but promising

* Beyond the scope

# ISSUES TO BE CLARIFIED TO MOVE FORWARD

## Market potential and segmentation

**U-235 content 5-7%**
LWRs >1 GWt(e)

0% — Shares - ? — 100%

**U-235 content 8-19,75%**
SMRs <0,6 GWt(e)

Market Demand - ?

## Issues to be solved for HALEU market developing

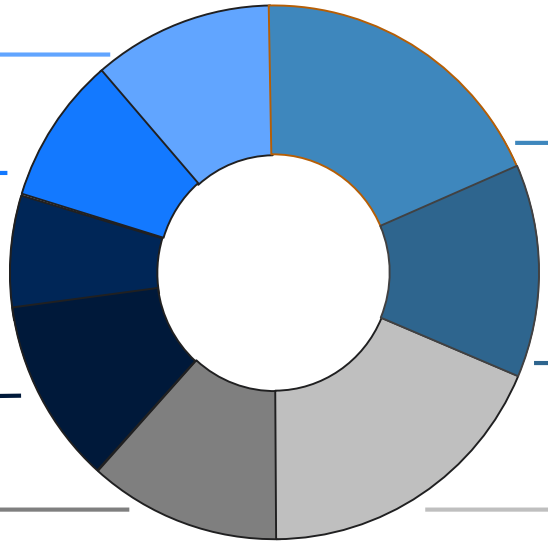
**Fuel design approved**

**Production capabilities updated**

**Transportation issues resolved**

**SNF management issues resolved**

**Facilities, Fuel etc. licensed**



**SMR projects run on time**

**Clear economic benefits confirmed by LWR operators**

**Regulations & Standards changed**

~ 3-5 years from now – estimated terms of full-fledged HALEU market emerging

# REQUIREMENTS FOR PACKAGES

## Existing packages

- TN-BGC (ORANO) for metal, oxide forms, solid materials, fuel rods, etc.

≤ 5 kg U-235 per package under US certificate(depending on form, U-235 assay); restricted cylinder qty. is available for lease on the market

- Versa-Pac (DAHER-TLI) for solid uranium materials, uranium oxides, uranium metal, UF6, etc.

less than 2 kg U-235 per package (depending on form, u-235 assay & package type); available for production

## Package under development

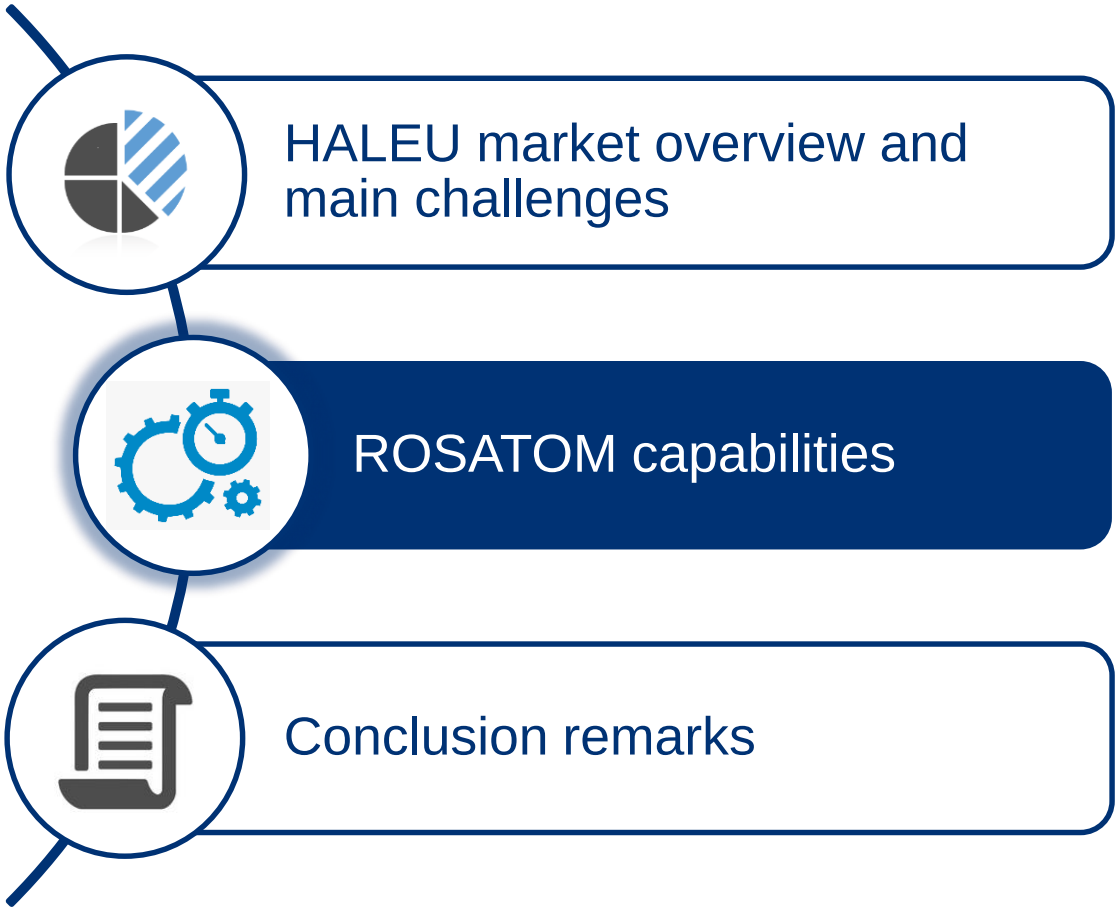
- DN-30-20 / 30B-20 (DAHER) for $UF_6$

≤320 kg U-235 (1600 kg $UF_6$) per cylinder; the concept needs to be designed, approved and manufactured

## Issues to solve

- Lack/restricted qty. of reusable package, unique for each common HALEU form (*metal, $UO_2$, $UF_6$, FAs*)
- Limitations on U-235 content per cylinder (*few packages allow commercial HALEU qty.*)
- Restrictions on shipping

# PRESENTATION CONTENT



# ROSATOM EXISTING HALEU PRODUCTION CAPABILITIES

## ROSATOM capabilities as of today:

Available licenses and approvals issued by federal competent authorities for production of HALEU enriched up to 19.75% U-235

- Technological capability to produce various forms of HALEU enriched up to 19.75% U-235:
  - Uranium hexafluoride (UF6)
  - Triuranium octoxide (U3O8 powder)
  - Uranium dioxide (UO2 powder)
  - Uranium metal (in ingots)
- Capability to produce HALEU enriched up to 19.75% U-235 from natural UF6 (minimum qty of unwanted impurities)
- Ability to adjust production capacities to potential customers' requirements (from several tens of kilograms up to several tons per year, depending on HALEU form and enrichment assay)
- Ability to supply HALEU material in metal and oxide forms within approximately 6-9 months from receipt of the order (depending on qty and form of HALEU, transport conditions)
- Capability to produce UMo, UAl alloys, UO2 pellets, fuel elements/assemblies/targets using HALEU material

# FACILITIES INVOLVED IN HALEU PRODUCTION




**Novosibirsk Chemical Concentrates Plant (NCCP)**

- Production of UO2, UO3, U3S2 powder, U metal, UMo, UAl alloys,
- Fuel & targets fabrication
- Unirradiated waste reprocessing capacity

**Siberian Group of Chemical Enterprises (SGChE)**

- Uranium conversion

**Production Association Electrochemical Plant (PA ECP)**

- Uranium enrichment
- Uranium deconversion
- Production of U3O8 powder

# PACKAGING, LOGISTICS, LICENSING

- Russian certificate (valid until March 2024) for transportation of HALEU enriched up to 19.75% U-235 in the form of metal and oxides in TNBGC-1 containers
  (≤7 kg U-235 per cylinder)

- No restrictions for issuing Russian certificates based on foreign approval certificates
  (approximately 9 months required to obtain the certificate)

- Multiannual experience of HALEU supply for research reactors overseas

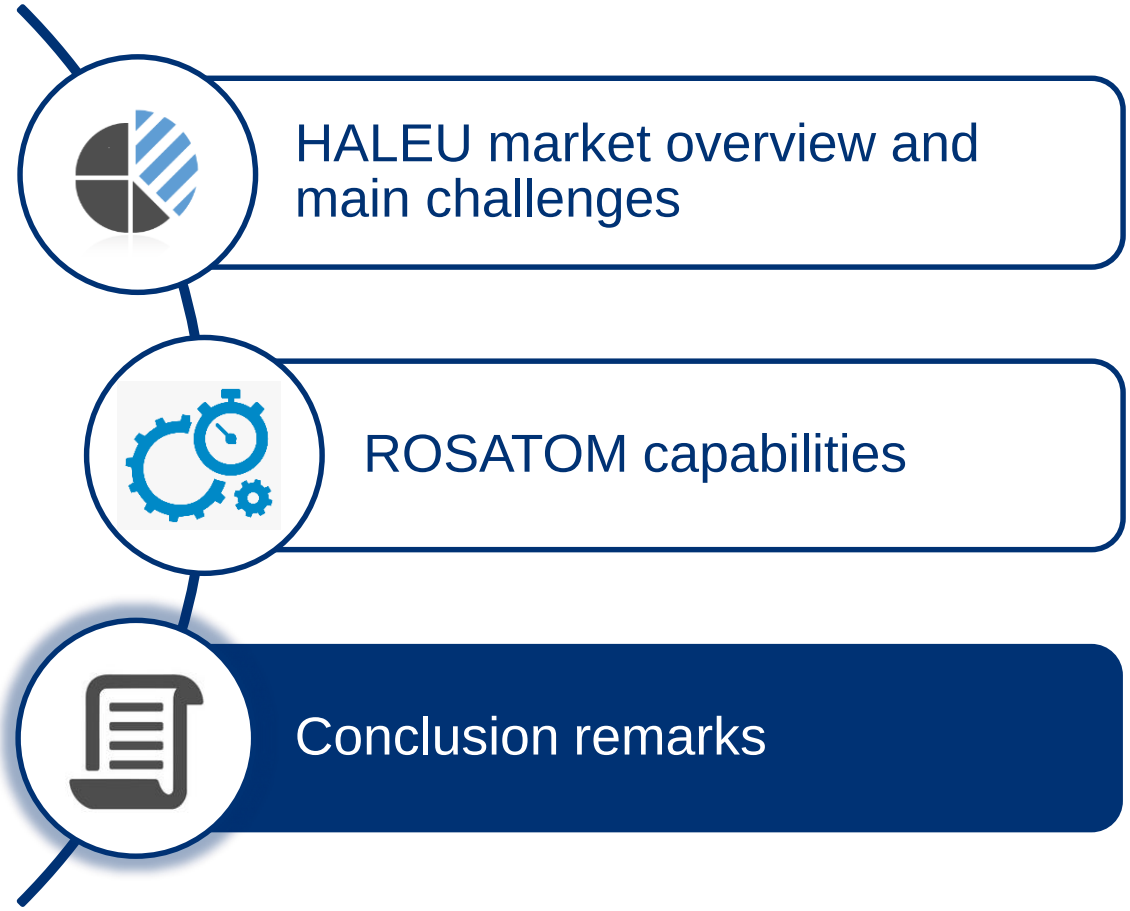
- Self-engineered packaging (TUK-159) for transportation of uranium metal and uranium oxides enriched up to 19.75% U-235

  - max 35 kg for U powder, max 50 kg for U metal according to Russian certificate
  - available for all types of transport
  - available for production

# HALEU FUEL FOR LWR

| Necessary prerequisites | ROSATOM competences | Next steps |
|---|---|---|
| Competence in **developing oxide fuel** | Many years of experience in production of LEU oxide fuel for power reactors | **Modeling and feasibility study** of HALEU use for LWRs |
| **SWU capacities** to provide >5% enrichment | >5% enrichment at ECP for RR fuel. AECC, ECP, SCP and UEIP participation in Megatons to Megawatts program. | Enrichment plants **licenses renewal for >5%** enrichment levels |
| **Fabrication capacities** for HALEU fuel | HALEU fuel fabrication for research reactors at NCCP. HALEU fuel fabrication for floating reactors and fast breeders at MSZ. | Certification and modernization of LWR **fabrication capacities for U-Er HALEU fuel** |
| **Transportation capacities** for HALEU fuel | Certified containers for research reactor HALEU fuel transportation | Container design, certification and production **based on the RR HALEU** fuel transportation container technology |
| More **effective burnable absorber** to keep high level of nuclear safety | Use of erbium in burnable absorber (20 years of experience with RBMK fuel) | **Uranium-erbium** HALEU fuel LTAs in VVER reactors |

# PRESENTATION CONTENT



# CONCLUSION REMARKS

- There is currently a small market for HALEU for research reactors, together with correspondingly small supply of HALEU and related infrastructure. Growth of the HALEU market, however, is now inevitable.
- Although current HALEU demand is relatively small, this demand is projected to grow slowly but steadily in the foreseeable future.
- The logical path to creating a reliable supply chain for HALEU is to use existing sources of production and facilities where possible while focusing time and attention on closing the gaps in this supply chain which are primarily related to transportation systems and logistics.
- Full international cooperation offers the most effective and efficient approach to assure reliable supply at the lowest costs and lowest risks.

# THANK YOU FOR ATTENTION!

We do believe that HALEU sustainable supply chain is a future of nuclear energy worldwide.

Let’s hinder them from falling down!