



THE NEW NUCLEAR
WATCH INSTITUTE

The back-end of low carbon technologies: Closing down nuclear fuel cycle

Chair:

Tim Yeo, Chairman, The New Nuclear Watch Institute

Speakers:

Kristina Gillin, Principal Consultant, Nuclear Waste and Decommissioning, Vysus Group

Rauli Partanen, CEO, Think Atom Ltd

Dr Ben Heard, Founder, Bright New World

Martin Porter, Secretary General, World Nuclear Transport Institute

Mikhail Baryshnikov, Head of Department for Innovation Products Development, TENEX

Management of spent fuel and radioactive waste – A sustainability perspective

November 26, 2020

Kristina Gillin

Vysus Group



Introduction

Implementation of nuclear waste disposal facilities – A reality check ...



It is time to reflect



- At paradigm level
- Using a sustainability lens

What is the problem?

- Multi-generational timescales
- Fragmented landscape
- Part of a bigger picture
- Industry's tendency to think:
 - Within the fence line
 - Until release from regulatory control
- Lack of true driver for implementation



Holistic approach needed

The nature of complex adaptive systems



- Self organising
- Constantly changing
- Non-linear
- Unpredictable
- Uncontrollable
- Can collapse

Cornerstones of a sustainability-based approach

Inclusive



Asset-
focused



Integrated



Vision-
based



Conclusions

- Surprises will occur – we need to plan for that
- Time to try new approaches
- Sustainability-based approach:
 - More logical
 - More likely to succeed
 - In line with general trends



Thank you

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SPENT NUCLEAR FUEL

WHAT KIND OF PROBLEM IS IT, ANYWAY?

NEW NUCLEAR WATCH INSTITUTE WEBINAR – NOVEMBER 2020

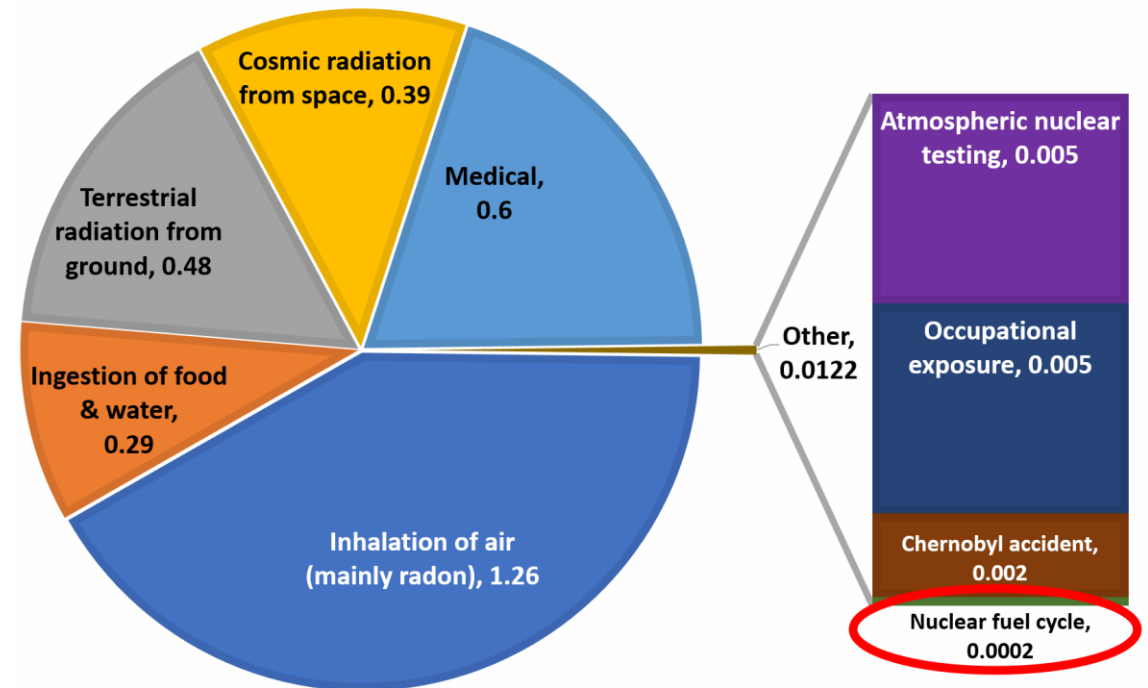
RAULI PARTANEN

THINK ATOM

NUCLEAR FUEL CYCLE AND PUBLIC HEALTH

- Spent fuel is so well managed that it has never hurt anyone.
- It gets less harmful with time.
- Deep geological storage has a safety margin of roughly one million times:
 - Absolute worst case scenario, max dose: 0.00018 mSv/year*
 - Threshold for health hazard: 100+ mSv / year

GLOBAL AVERAGE RADIATION SOURCES,
MILLISIEVERTS / YEAR

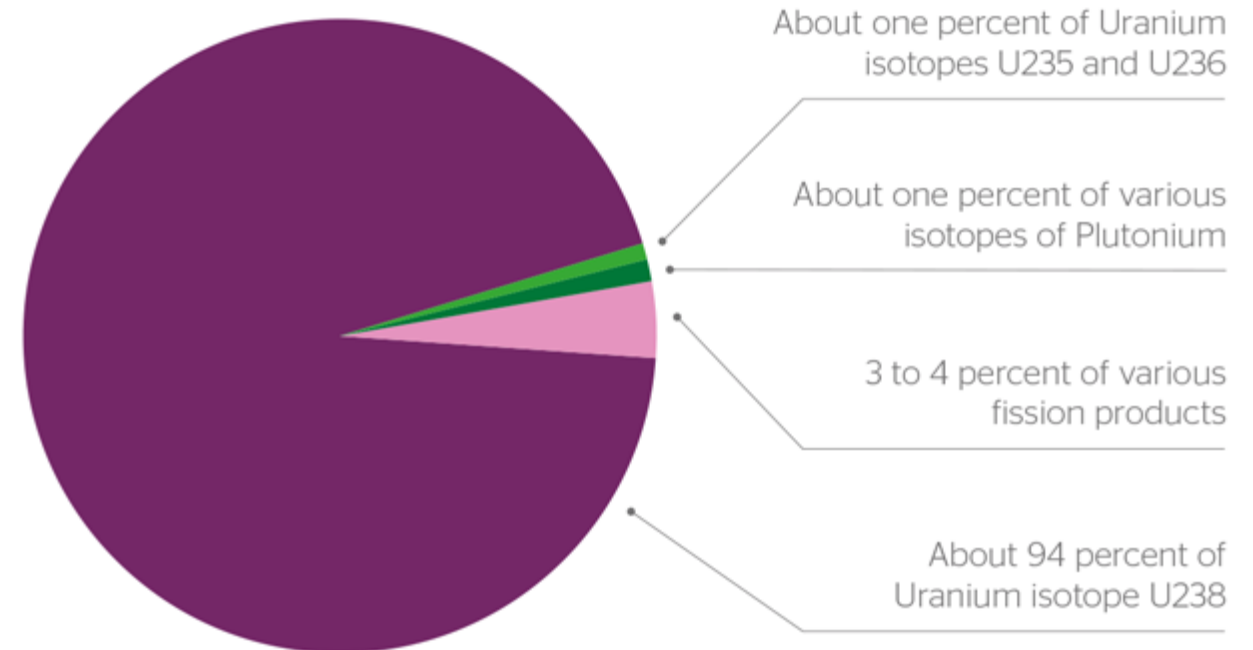


* Based on Onkalo Deep Repository's environmental assessment.
http://www.posiva.fi/files/3195/Posiva_2012-10.pdf

ENGINEERING OR ECONOMIC CHALLENGE?

- Multiple solutions are available:
 - Dry casks above ground.
 - Geological repository.
- Real question is: Do we want to have easy access to it later on, as a source of fuel in next generation of breeder reactors?

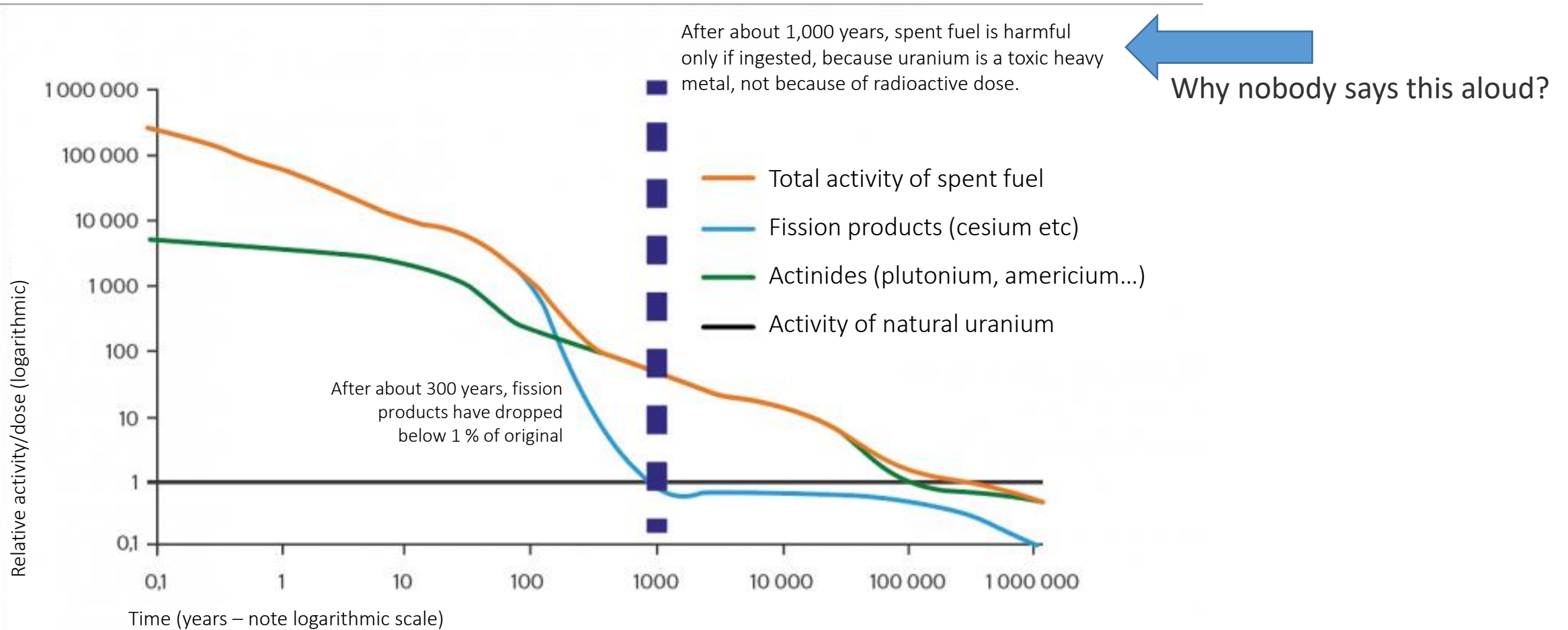
Spent fuel contents:



IS THERE A POLITICAL PROBLEM?

- Any nuclear waste solution needs a political decision to happen.
- Spent fuel issue is politically “toxic.”
- Often politicians can only *lose* by trying to solve the issue, so they don't.
- Hence, there is an “unsolvable” waste problem.

SOLVING THE WRONG PROBLEMS?



SUMMARY

- Spent fuel is mostly a political problem, not a public health or an engineering problem.
- The industry has been solving a political problem as if it were public health or engineering problem.
- Is this (part of) the reason “solving it” has been so hard?

Food for thought:

Should we start solving the political / public acceptance problem instead of trying to solve the (non-existent) public health problem?

THANK YOU.

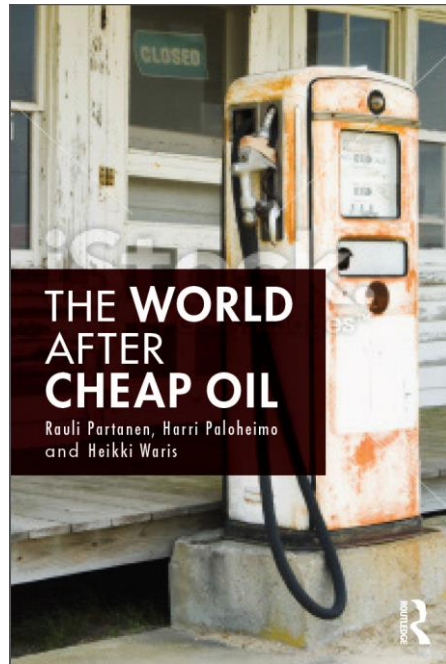
RAULI PARTANEN

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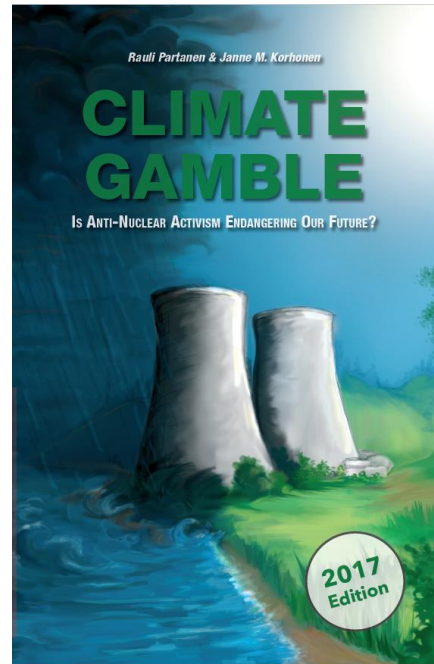
RAULI WHO?

- 🔬 Science writer & analyst
- 🔬 Activist (Ecomodernist Society of Finland)
- 🔬 Co-founder & CEO of Think Atom

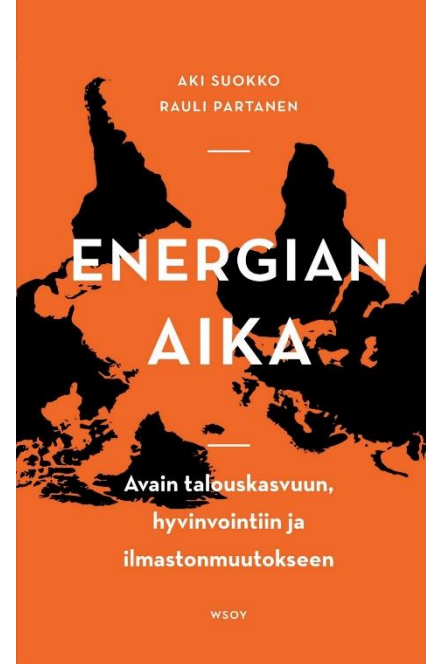
Sciencebook of the year



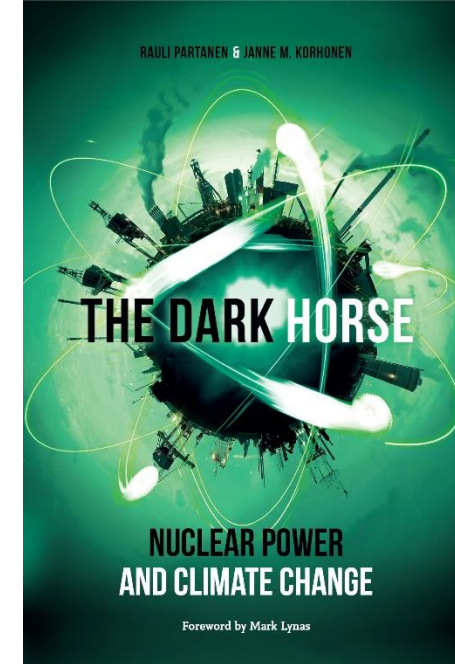
2014



2015



2017

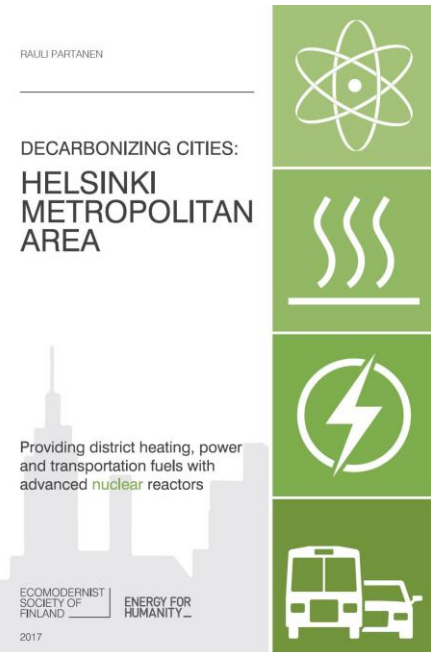


2020

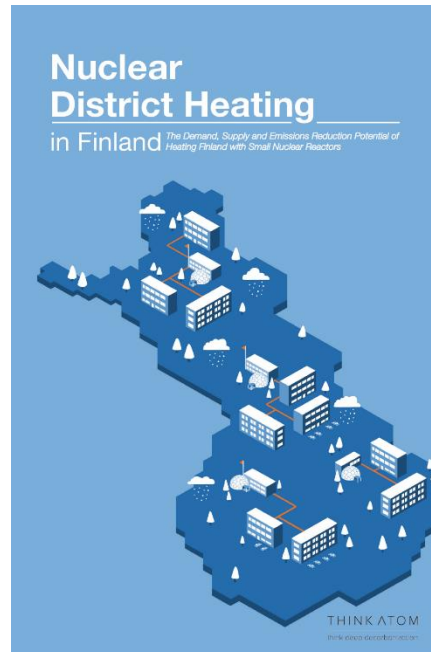
WHAT IS THINK ATOM

- ☼ Non-profit, independent think tank & consultancy.
- ☼ In a nutshell: How to use nuclear to decarbonize different sectors of our economy (power, heat, transportation).
- ☼ <https://thinkatom.net/publications/>

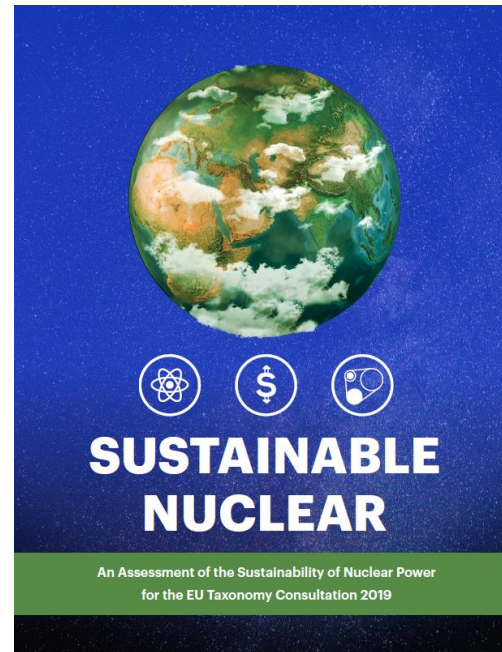
(contributor)



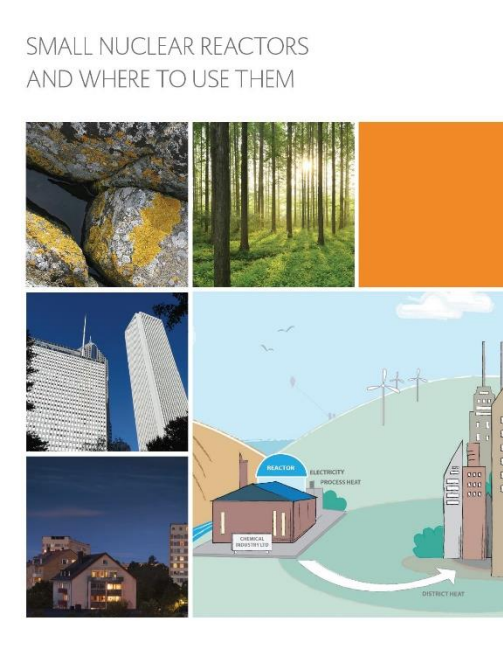
2017



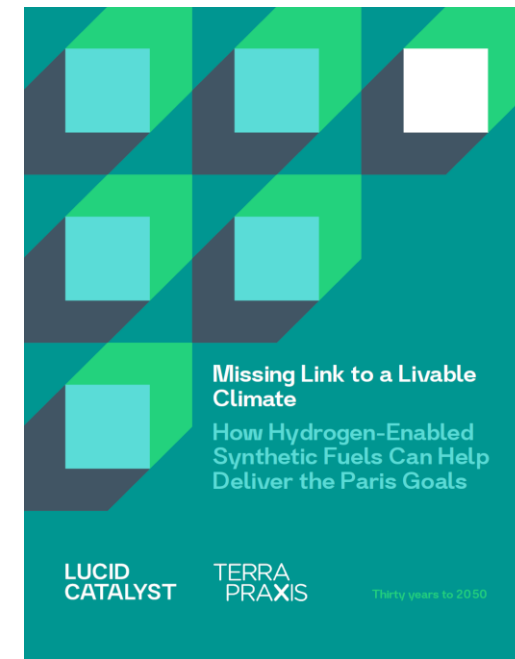
2019



2019



2020



2020



Dr Ben Heard

Founder, Bright New World

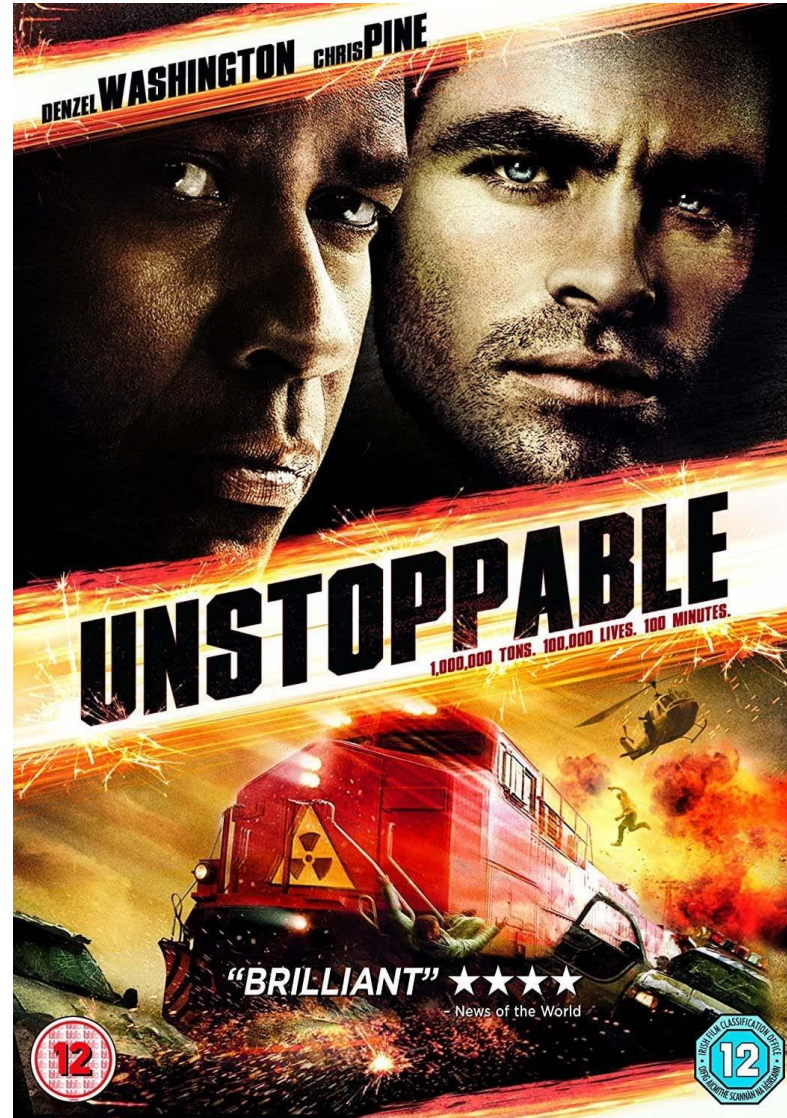
World Nuclear Transport Institute

*The UK Nuclear Evolution – Learning From
Experience*

Martin Porter – Secretary General
26 November 2020

- Perceptions of nuclear transport
- UK nuclear timeline
- Challenges
- Opportunities

- Begin with powerful story line loosely based on a real event
 - A train carrying phenol suffers a series of mishaps and runs away without a driver
- Embellish the facts with some high drama
 - The train careers towards a sleepy town with lots of well-meaning people
- Secure the services of some A-list actors
 - Denzil Wasington, Chris Pine et al.
- Draw in the audience with a powerful advertising campaign
 - Unstoppable: 1,000,000 tons, 100,000 lives, 100 minutes
- Enjoy the success
 - \$167,000,000 grossed and an Oscar nomination



1947 – Ministry of Supply begins the Sellafield with the primary purpose of Windscale being to produce defence material. (Concurrently, Springfields is developed to manufacture nuclear fuel).

1956 – Queen opens Calder Hall, the world's first commercial-sized nuclear power plant.

1957 – Windscale Pile 1 fire.

60's & 70's – Reprocessing and enrichment added to the programme

1983 – 'Windscale The Nuclear Laundry' broadcast on UK TV

- Energy Act 2004 lays foundation for large-scale decommissioning
- Formation of Nuclear Decommissioning Authority supplemented by PBO/subsidiaries
- Focus on environmental remediation

- Magnox reactors defueled
- AGR reactors approaching phased cessation of generation
- Commercial (THORP) reprocessing ended
- Domestic (Magnox) reprocessing programme coming to an end
- Contracted High Level Waste returns nearing completion.
- Reactor site and Sellafield decommissioning programme underway.
- Geological disposal facility (GDF) is planned for second half of the century
- Reactor new-build in its early stages

- Perceptions of radioactive material operations are not always objective or scientific. Delays and denials of shipment remain as tangible risks to sea and air transport.
- The transport regulatory framework is not yet fully aligned to exploit some technological and operational advancements. Regulatory revision is a protracted process.
- Geological disposal as an end-state is still the subject of considerable debate.

- Redressing the waste site capacity challenges. Blanket coverage approach to waste characterisation now replaced by informed application of the waste hierarchy. Waste volumes being reduced by ‘extracting’ the radioactive portion. Concrete and metal being recycled up to free release.
- New approaches to managing spent fuel being worked up. Flask repurposing to dual-use (transport and medium-term storage) an option. Engagement with regulators is enabling new ways of working.
- Low carbon transport is available. New rail technology offers 76% less carbon emissions than road for equivalent payloads. Electricity offers zero emission rail transport. Mixed loads enable more efficient rail transports.

- UK nuclear programme is moving from 'old' generation and reprocessing to new generation, decommissioning and remediation.
- Nuclear materials have been transported for many decades without serious incident of release.
- The storage, transport and disposal of radioactive materials stimulates emotive debate.
- Many environmentally-positive innovations are helping nuclear to drive and realise carbon reduction.
- Enablement and encouragement from policy-makers and regulators is opening up opportunities. Key to progress.

Further information is available from WNTI:

- Website: www.wnti.co.uk
- Email address: wnti@wnti.co.uk
- Office: WeWork Aviation House, 125 Kingsway, London, UK.
- Telephone: 0207 580 1144





TENEX
ROSATOM

Innovative Solutions in the field of Used Nuclear Fuel management

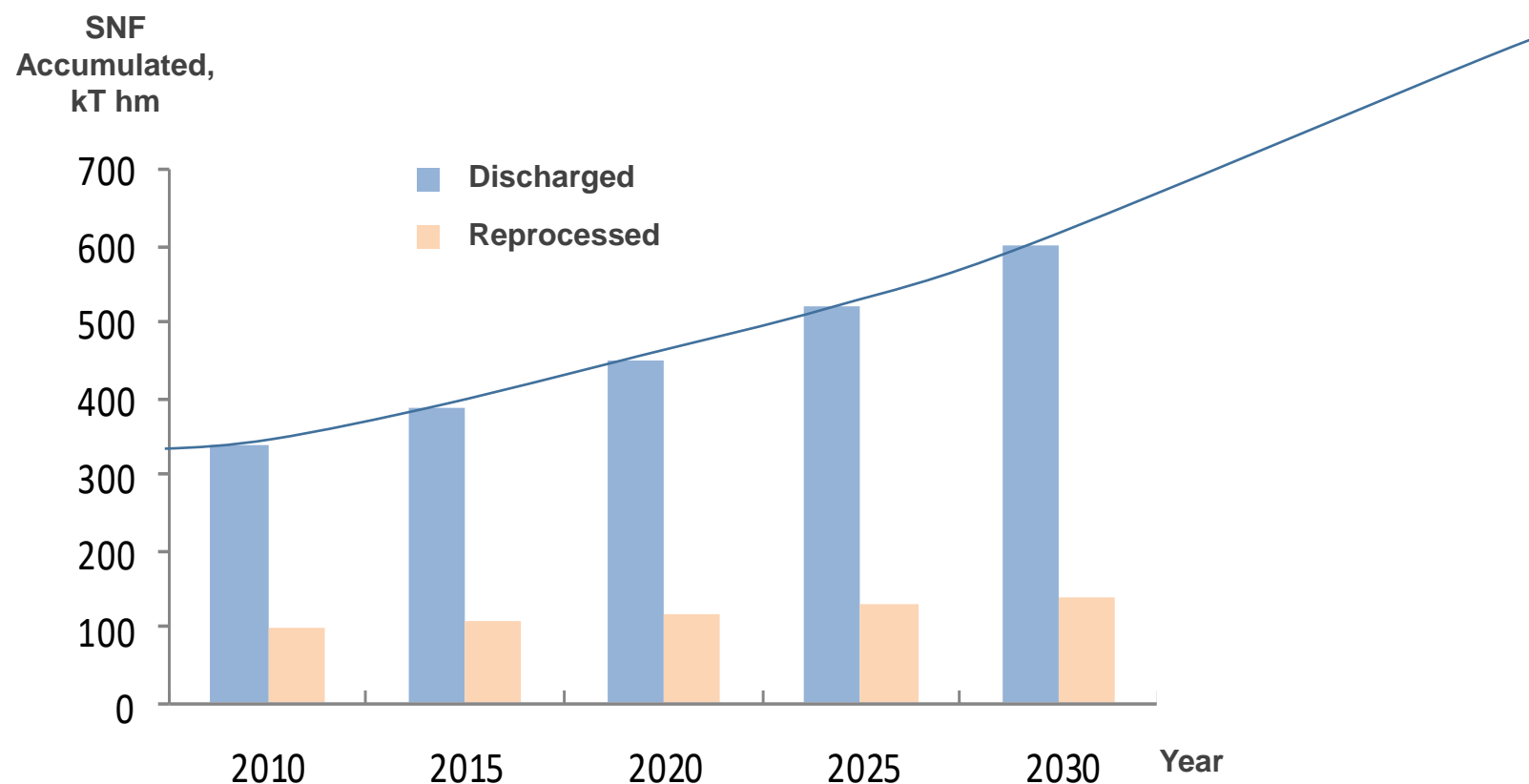
The New Nuclear Watch Institute Workshop 'The back-end of low-carbon technologies.
Closing down nuclear fuel cycle'.

Webex, November 26th, 2020

Mikhail Baryshnikov

Director, Department for Innovations and Technologies, TENEX

Growing Nuclear: More Used Nuclear Fuel Generation



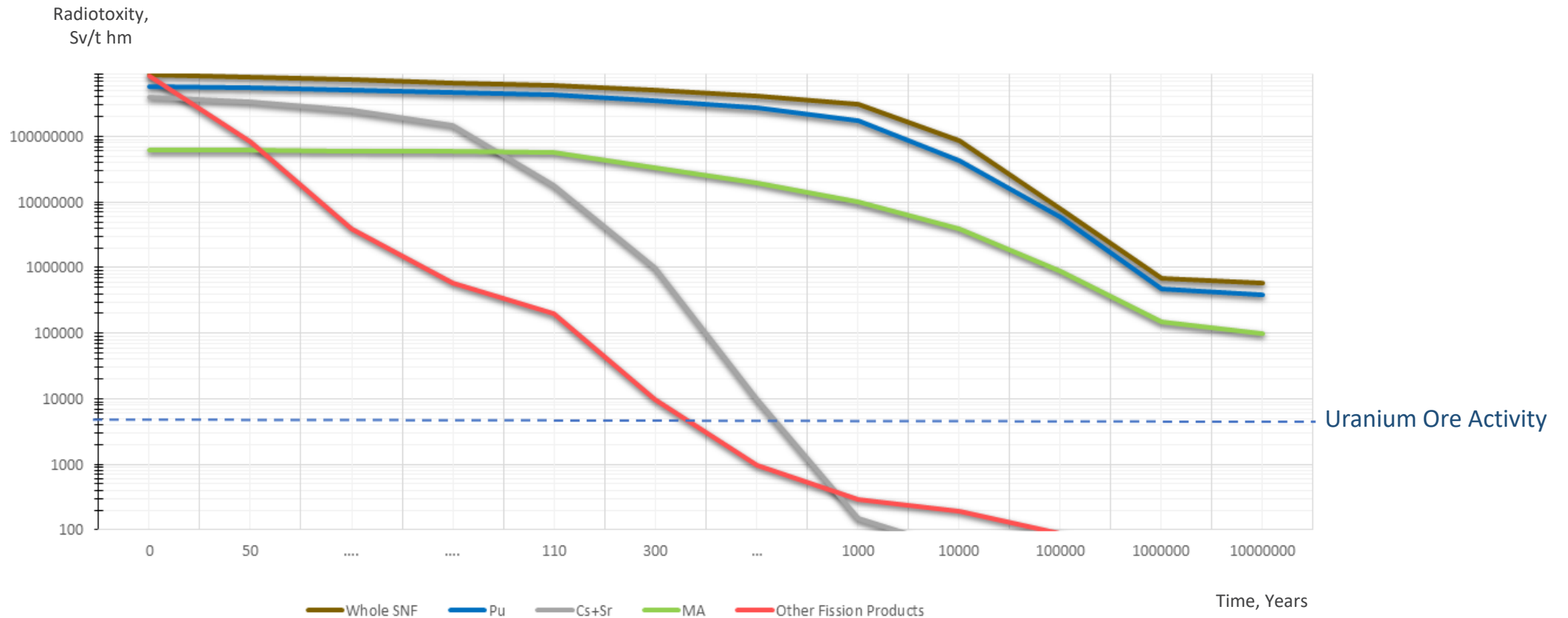
Vision of SNF volume worldwide accumulation rate
calculated for current NPP fleet size and SNF reprocessing rate

Key Requirements for the New Nuclear Fuel Cycle

- ✓ **To decrease considerably amount and danger of waste to be disposed**
 - Obligatory UNF reprocessing.
 - High level waste partitioning with the separate treatment of the different fractions.
 - Minor actinides transmutation.
- ✓ **To enhance fissile materials consumption**
 - Multi-recycling of U and Pu.
 - Pu 'cleaning' in the fast reactors.
- ✓ **To comply with non-proliferation regime**
- ✓ **To be appropriate to reactor fleet**
Taking into account specifics of LWR, PHWR and FR

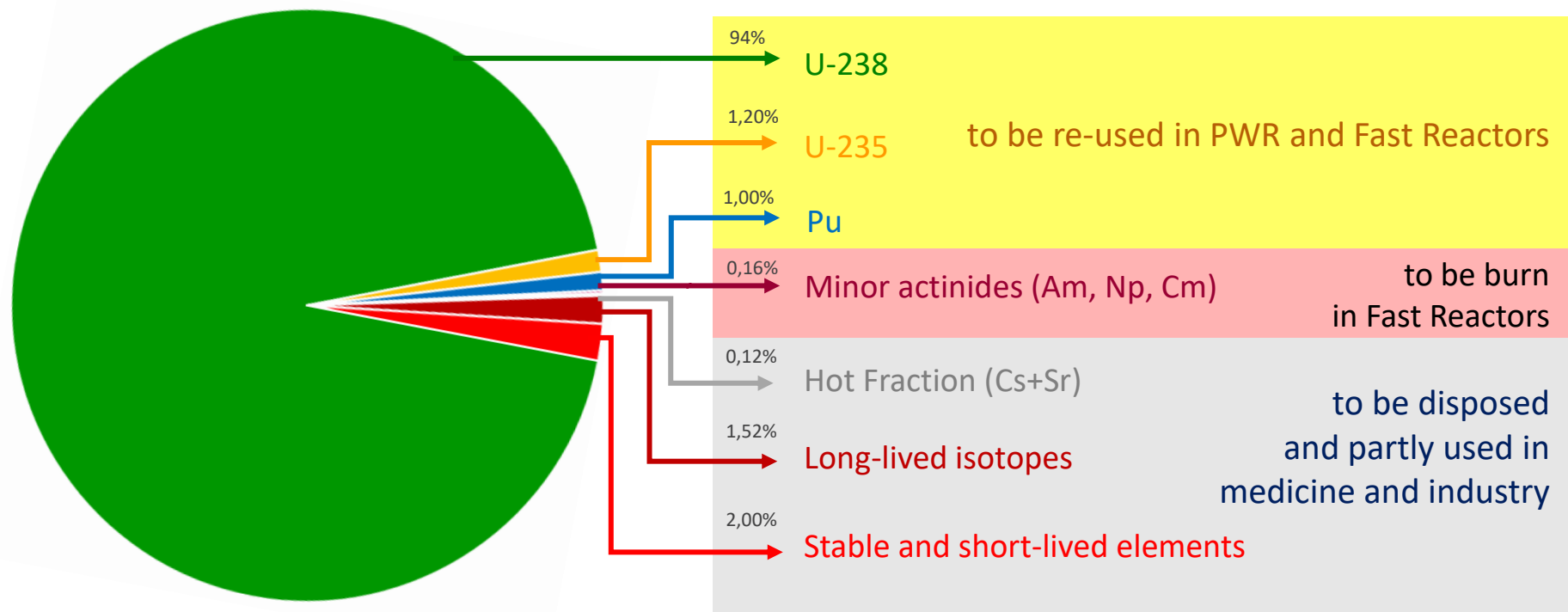


Used Nuclear Fuel is Quite Specific to be Directly Disposed Better to split it and manage by fractions



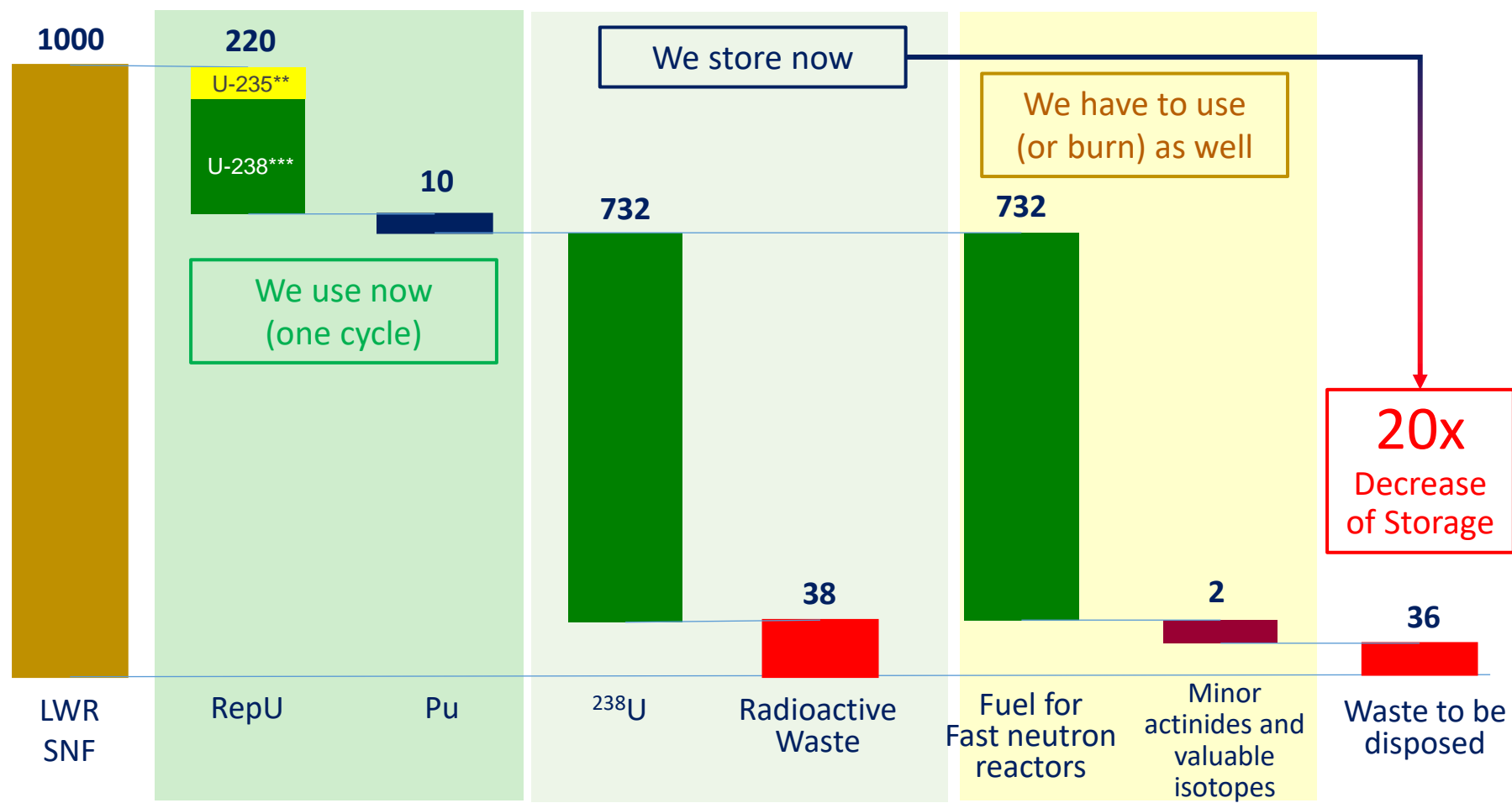
Nuclear Waste components radiotoxicity decrease

What to do with the different UNF fractions After partitioning



SNF components possible usage

UNF Partitioning Allows to Minimize NatU Consumption and Amount of Waste



Spent Nuclear Fuel Composition, reference kg*

*Expert estimation for SNF after 10 years of cooling **As reprocessed uranium in UO₂ fuel ***In MOX fuel

ROSATOM offers different innovative solutions in the field of UNF management

- **Comprehensiveness:** recycling of the useful materials (U, Pu, valuable isotopes) and minimization of the volume and danger of the waste to be disposed.
- **Emphasis on advanced scientific and engineering achievements:** involving the partitioning technologies, fast reactors, the best practices in the field of geological disposal of radioactive waste treatment.
- **Customizing:** ability to offer the Customer optimal NFC options
- **International cooperation** enhancement in different forms.



ROSATOM offers different innovative solutions

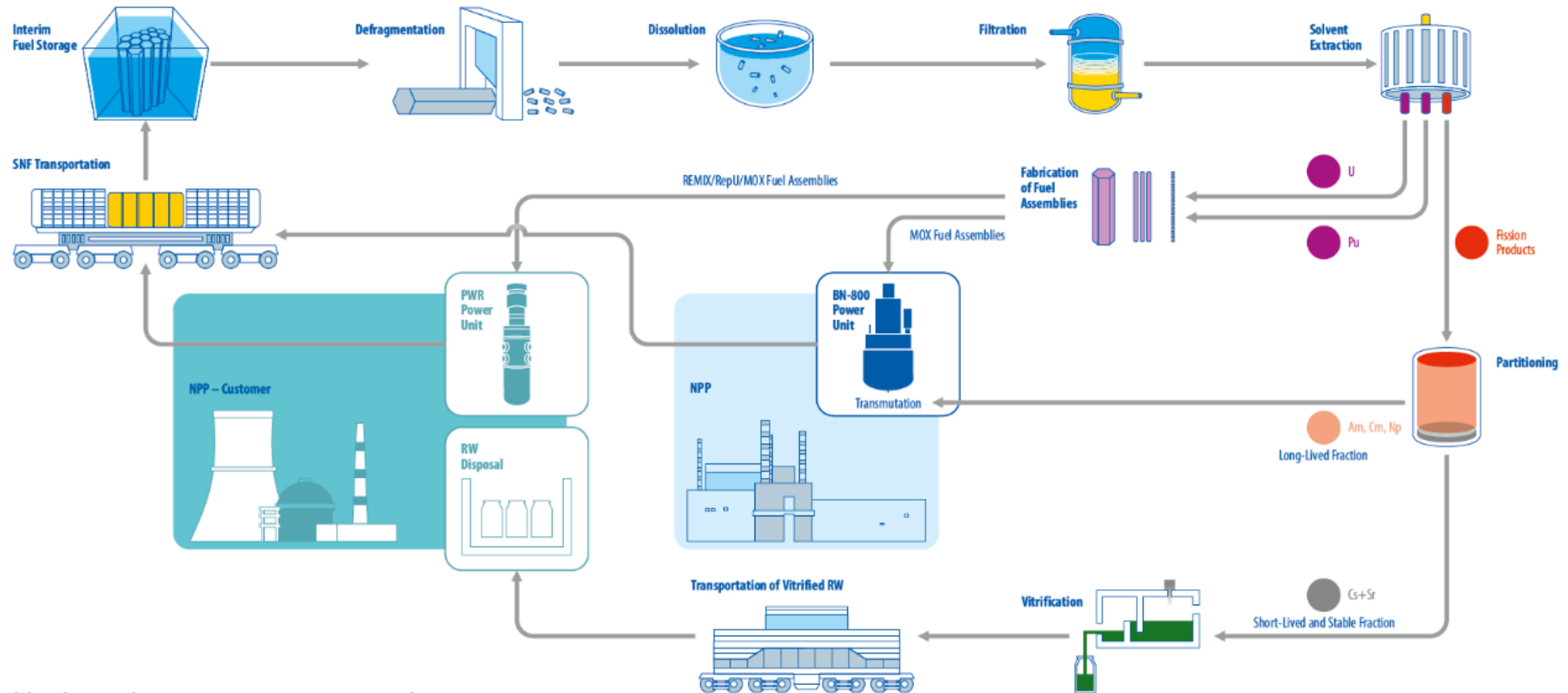
Naked Examples



- **Recycling of the reprocessed Uranium in existing LWR.** All the Russian RMBK type reactors (9 units of 1GW up to date) and one VVER type (Kola-2, 0,5 GW) are powered by RepU-fuel. ROSATOM serves EDF in purifying and enrichment of French RepU. Fennovoima NPP is contracted for RepU-based fuel. The program is in expanding RepU feeding for VVER-1000/1200.
- **Recycling of the Pu recovered from the Used Nuclear Fuel.** BN-800 Fast reactor is powered by MOX fuel made of the Pu extracted from VVER used nuclear fuel. REMIX fuel is designed as a 'light MOX' for multi-cycled usage in LWR. ROSATOM is ready for service of effective Pu utilization in its own NPP.
- **UNF recovered isotopes production.** **Sr-90** is used for as a long time (~30 years) heat source; **Cs-137** is widely used in gamma flaw detection, measurement techniques, food sterilization, pharmaceuticals, tumors radiotherapy, etc. **Pu-238**: NASA's Perseverance Mars rover [successful launched from Cape Canaveral on July 30, 2020] is fed by reliable power source converting heat from a Pu-238 source; **Cm-244** is the raw material for the most expensive material in the world – californium: its official price in 2015 was 6.5 mln USD for 1 g; it is used on radiation therapy of tumors and spontaneous nuclear fission studies.
- **Sustainable [Balanced] Nuclear Fuel Cycle.** Includes solutions both in fissile materials recycling and radwaste disposal.


Balanced Nuclear Fuel Cycle

All the Russian UNF innovations in one place



Sustainable Nuclear Fuel Cycle

Complex of the Main Recycling Components



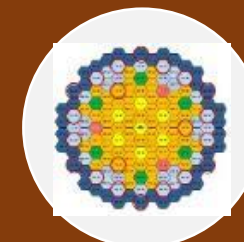
Effective Package



**UNF
Reprocessing &
HLW Fractioning**



**Recovered
Nuclear
Materials Fuel
Fabrication**



**Minor
Actinides
Trans-
mutation**

- Solutions in preparation and transportation of SNF to the Russian Federation and to return of HLW to the Customer: delivery of "turnover" TUK, the interim storage for the purpose of forming of the transport batch, temporary technology storage of SNF and HLW in the Russian Federation
- Development of infrastructure for HLW long-term storage and/or final isolation (geological disposal) at the Customer's site; includes delivery of "non-returnable" casks

- Radiochemical reprocessing of SNF in the Russian Federation with recovering of RepU and Pu
- Partitioning of the HLW for the purpose of "short-lived" fraction (Cs+Sr) separation
- Return of the "short-lived" fraction to the Customer. Adaptation of the HLW returned to the Customer's infrastructure
- Long-term storage in the Russian Federation of the "long-lived" fraction, and temporarily unclaimed regenerated fissile materials, with their possible subsequent use, transmutation and conditioning for final disposal

- Fabrication of fresh fuel (MOX, REMIX, RepU) of the fissile materials recovered of the SNF
- Delivery to the Customer of the fuel made of RepU or U-Pu according to the program of fuel supply with replacement of natural uranium and with exception of accumulation of Pu, superfluous for development of the local nuclear industry
- Ensuring the maximum recycling of fissile materials in the existing reactor fleet

- HLW partitioning with separation of americium, neptunium, curium.
- Fabrication of elements (Am-rods) allowing to place minor actinides in the fast neutron reactor core.
- Long-term storage of Cm for its transmutation to Pu
- Am-rods irradiation in the fast neutron reactor during the standard campaign.
- Am-rods reprocessing with RW conditioning

Prospective of Implementation



Alexey Likhachev,
ROSATOM CEO

IAEA Ministerial Conference
“Nuclear Power in the XXI century”
September 17, 2018

«We are certain that **the future of world atomic energy is intrinsically linked to closing of the nuclear fuel cycle**, and fast reactor technologies constitute an integral part of it...Considering the scientific and technological backlog we are convinced that the **closed fuel cycle** is no longer a distant prospect. And we are basically witnessing the first stage of this project’s implementation today. Closing of the fuel cycle will allow peaceful atom to become an environmentally safe source of energy with practically inexhaustible resources for millennia to come. There are all grounds to believe that such a comprehensive product will be offered to the market **within the next 10-12 years**. In terms of nuclear energy, it is almost tomorrow»

Resume

- In concern of Nuclear Power growth amount of the used nuclear fuel is to be increased.
- The most reasonable solution is the new nuclear fuel cycle, based on rational approach to the UNF content.
- ROSATOM is considered itself as a leader in the promotion of sustainability in the nuclear fuel cycle development.
- Innovative solutions have to make sustainable UNF management.
- The works are in progress. Results seem to be on the market in a decade.

Thank you for your attention!

Mikhail Baryshnikov

Director, Department for Innovations and Technologies, TENEX, ROSATOM Group

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www.rosatom.com

26.11.2020





THE NEW NUCLEAR
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Any questions?

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