RADIOACTIVE LIQUID WASTE TREATMENT USING NURES® ION EXCHANGE TECHNOLOGY

for Safe and Cost-Efficient Long-Term Operation

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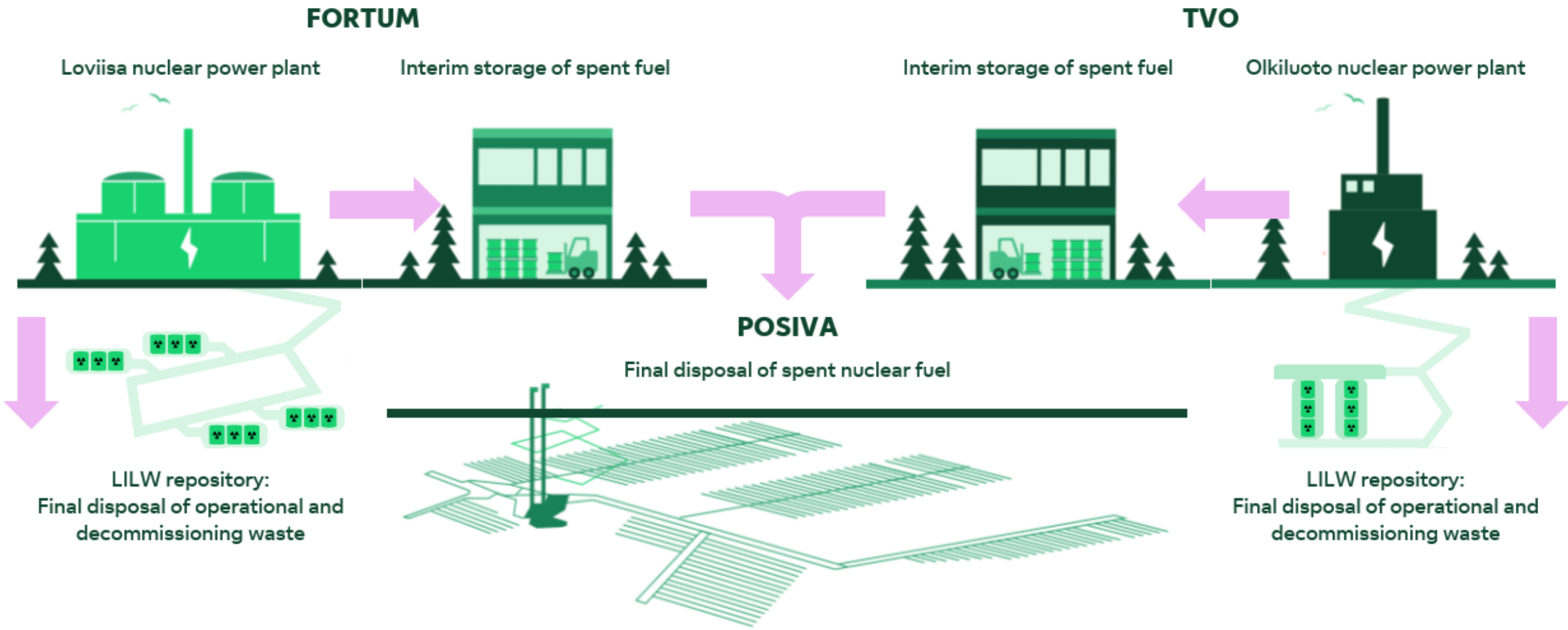
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Importance of Radioactive Liquid Waste Management

Safety	Safe and stable final state of waste → environmental and human safety
Cost Efficiency	Volume reduction for easier and cheaper disposal
LTO	Ensures continued regulatory compliance, minimizes operational risks and waste storage constraints and supports safe, reliable, and economically sustainable plant operation over extended lifetimes
Public Opinion	Affects public opinion towards a solution/technology, simultaneously affecting the nuclear industry as a whole

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Radioactive Waste Management in Finland



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NURES® – Liquid Waste Management



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Overview of NURES® Waste Treatment

- Fortum´s own NURES® (Nuclide REmoval System) technology purifies liquid radioactive waste to a fraction of the original waste volume
- The technology was originally developed in the 1980s for a cesium removal process at the Loviisa NPP
- Since then, the product portfolio has been expanded to include four ion exchange materials
- Fortum's NURES® technology is based on patented, 100% inorganic, highly selective ion exchange materials
- The cost of disposal is usually high per unit of volume. Radioactive waste cannot be eliminated, but the volume can be reduced
- NURES® technology has been used for over 30 years and reached over 100 users worldwide

References

- ALPS system, Fukushima
- Grafenrheinfeld NPP, Germany
- Paks NPP, Hungary

Core of the technology is four different ion exchangers

CsTreat®

SrTreat®

CoTreat®

SbTreat®

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NURES® for Radioactive Liquid Waste Treatment

- The treatment of radioactive waste requires specifically designed materials with intricate requirements including:
  - High radiation tolerance
  - Tolerance towards elevated temperatures
  - High selectivity for the radionuclides in trace concentrations
  - High capacity
  - Mechanical and chemical stability for long periods of times
  - Compatibility with final disposal criteria/conditions
  - Providing a maximum volume reduction and minimizing the disposal cost and environmental burden
- As inorganic and highly selective ion exchange materials, **NURES® fulfills all the requirements** and provides significant volume reduction even in challenging conditions.

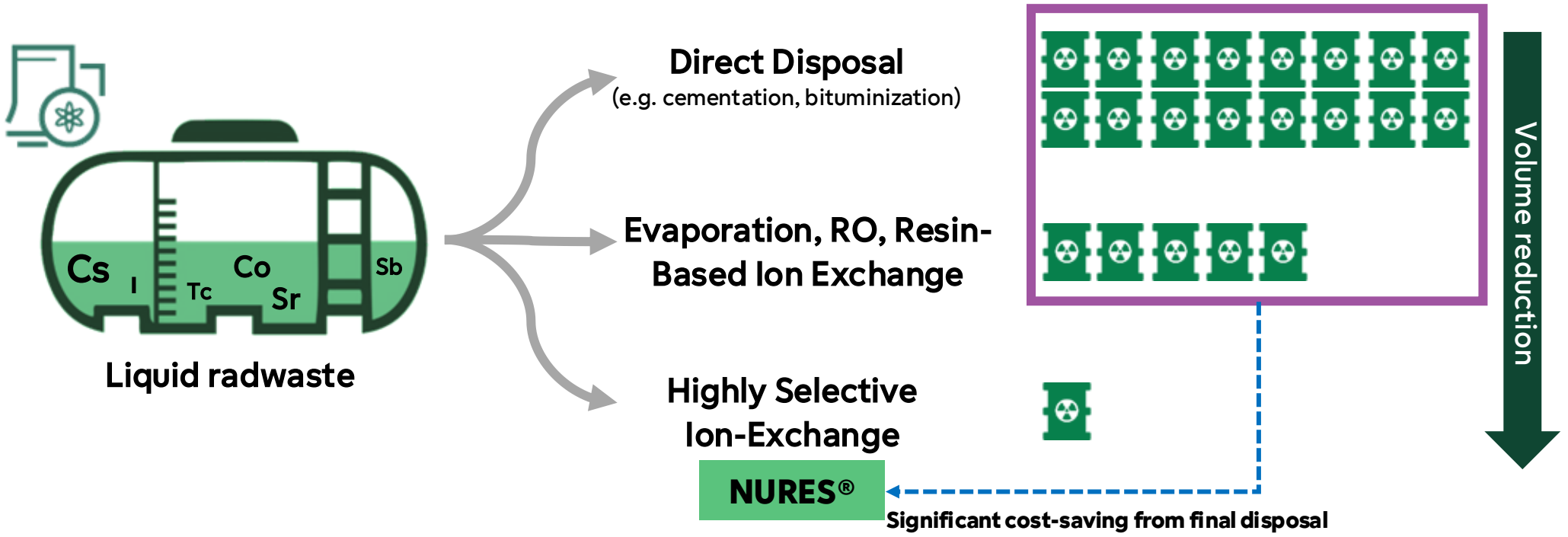


Fortum's NURES® products

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Cost-Savings Achieved by Using the NURES® Product

- Macroeconomics of the NURES® product
  - Volume reduction of liquid radioactive waste streams



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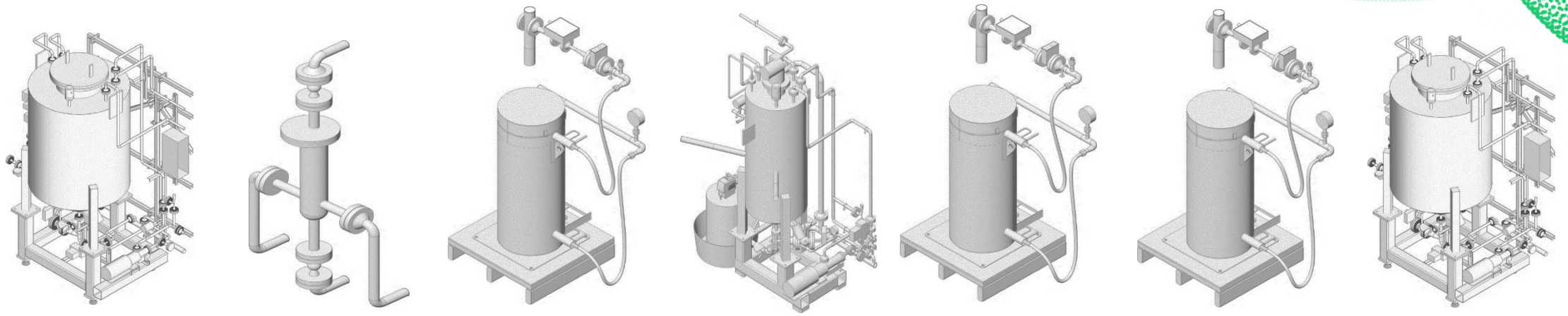
NURES® Main Component : Ion Exchange Filters



- The ion exchange material is stored in a disposable filter column
- The treated liquid flows through the column, the column captures the radioactivity
- The filter depletes based on characteristics of the treated liquid and needs to be exchanged periodically
- The column will be dimensioned according to specifications of the final disposal container, characteristics of the treated liquid and required performance (e.g. desired flow rate)

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Example NURES®-process



Collection tank → Mechanical filtering of solids → SbTreat® → pH-adjustment & mixing → CoTreat® → CsTreat® → Clearance tank

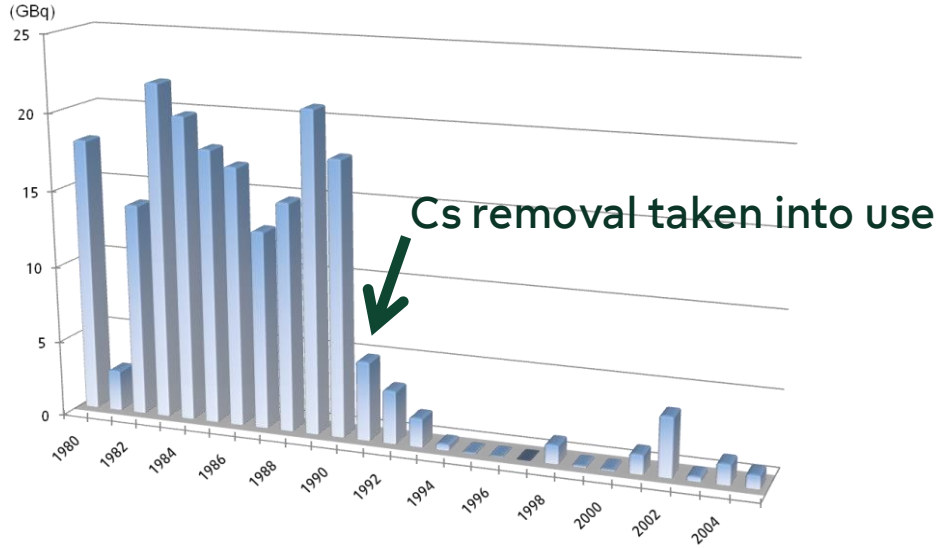
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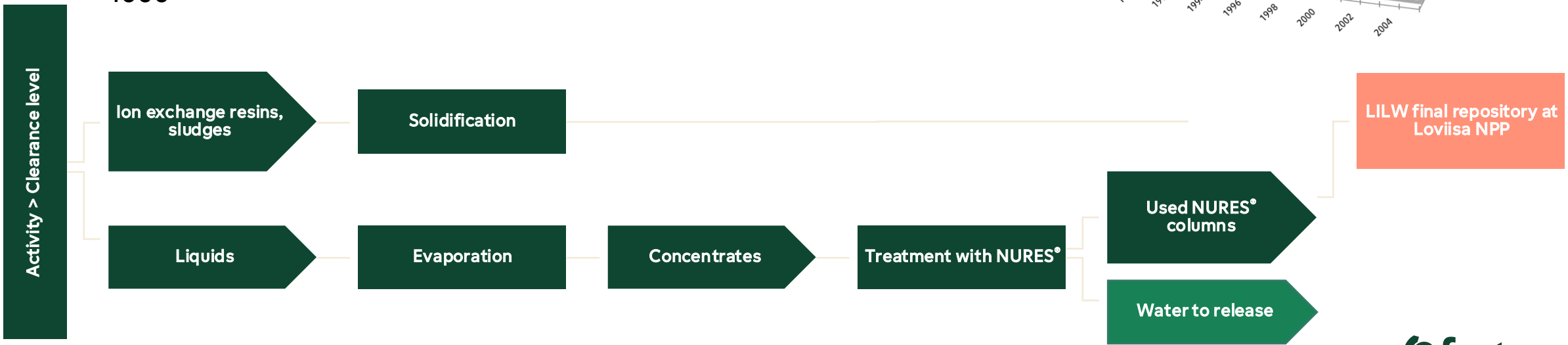
NURES® System at Loviisa NPP Finland

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Liquid Waste Treatment in Loviisa NPP, Finland

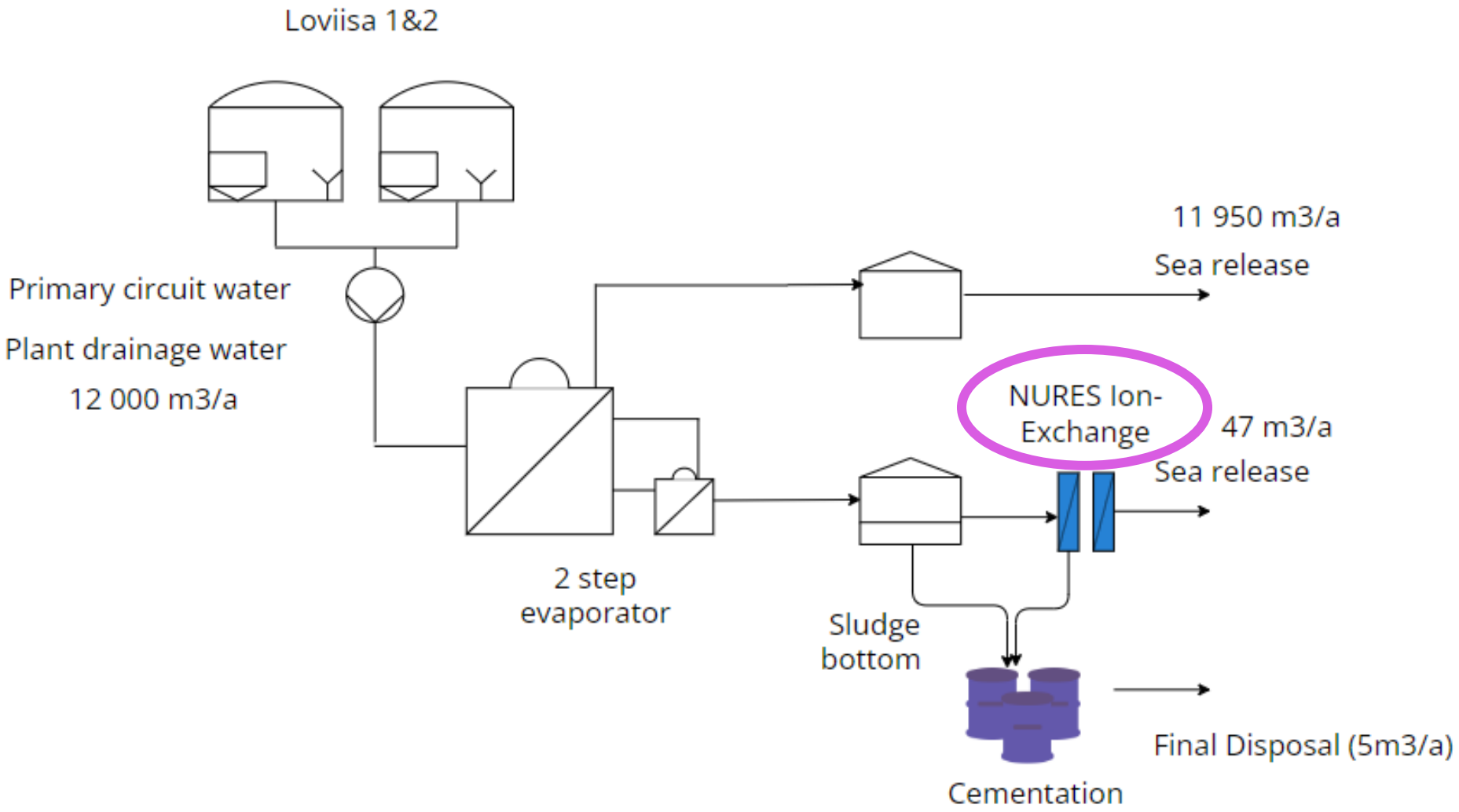
- NURES® CsTreat has been used in Fortum's Loviisa NPP in Finland since the early 1990s
- 2000 m^3 of evaporator concentrates have been treated by the end of 2024
  - Considerable cost saving (~ 50 M€) compared to solidification
  - 856 L of CsTreat® has been spent (8-L columns -> 107 columns in total)
  - Decontamination factor for Cs has been in the region of 1000





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Loviisa NPP Liquid Waste Management – Process Overview



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NURES® Facility at Loviisa NPP

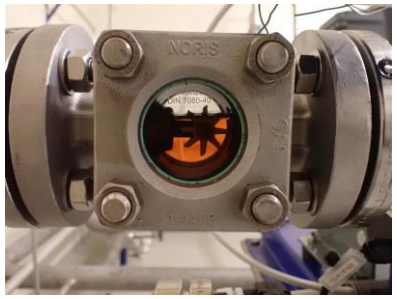
- The NURES® system consists of:
  - Tank
  - Two stage mechanical filtering
  - Two CsTreat® columns
  - Lead shielding
  - Sampling station
  - Automation, pumps, piping
- The evaporator concentrate is collected for four years and treated in ~200m^3 batches
- About 40-50m^3 are treated with one 8- liter column

→ 6200- time volume reduction









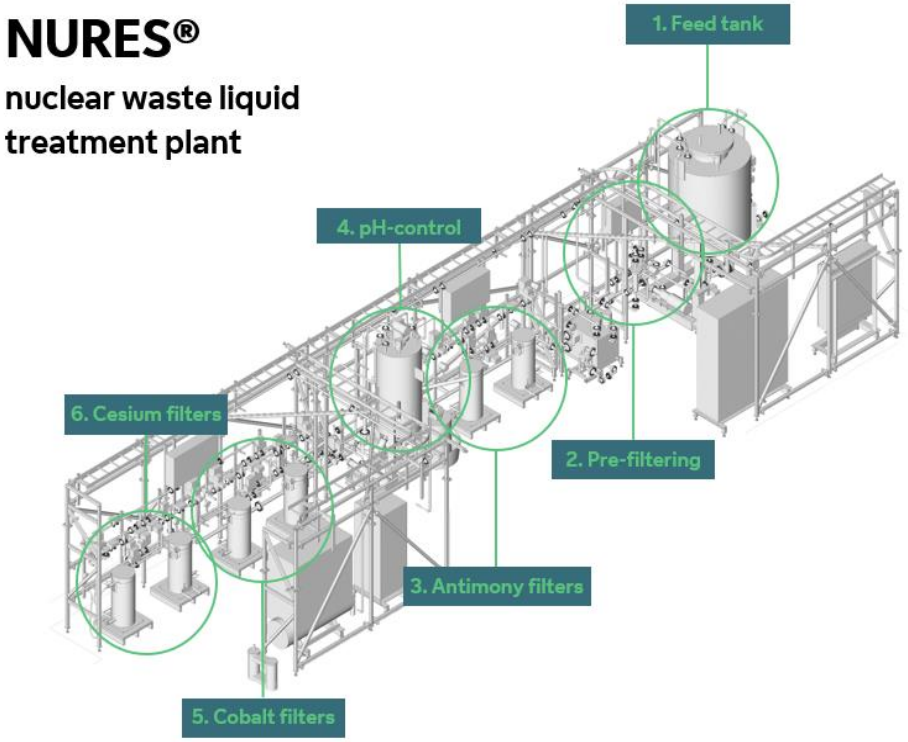


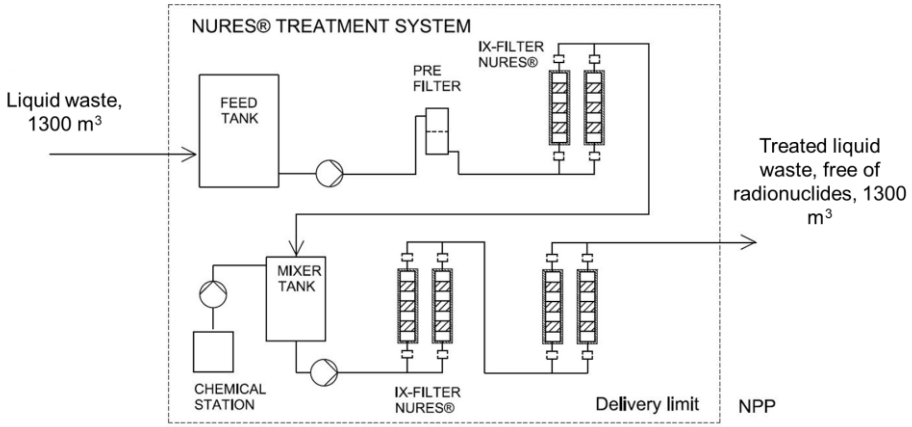
NURES® System Delivery to Germany

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Full System Delivery to Germany

- Fortum delivered a mobile liquid waste treatment system to Grafenrheinfeld NPP in Germany
- The system occupied a room of 40 m^2 size
- Treatment capacity: 20 to 30 m^3 / week
- Highly automated, less than 30-min manual work needed per day
- Approximately one year from order to take-over
- Operation started in 2020 & finished in 2022
- A total of ~150 liters of ion exchange material was used to decontaminate 1300m^3 of radioactive liquid waste
- Decontamination factors were between DF100-1000 depending on the incoming activity





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Key Takeaways

1

Safe and sustainable LTO

Effective liquid waste management supports regulatory compliance, safe operation and sufficient waste-storage capacity throughout extended plant lifetimes.

2

Minimal waste & cost efficiency

NURES® inorganic ion exchangers selectively remove key radionuclides, enabling major volume reduction even under demanding process conditions.

3

Adaptable and internationally proven performance

Modular NURES® solutions can be tailored to different waste streams and plant needs. NURES® technology has been used for over 30 years and reached over 100 users worldwide.

NURES® combines safety, operational practicality and disposal-cost efficiency in one proven treatment approach.

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THANK YOU!

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