Full conversion of IRE ^{99}Mo, ^{131}I & ^{133}Xe process to LEU : impact on radioxenon emissions

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Overview

- Impact of the LEU conversion on the process
- Comparative radioxenon emissions of HEU vs LEU
- Technical tour
- Current and future improvements

Context

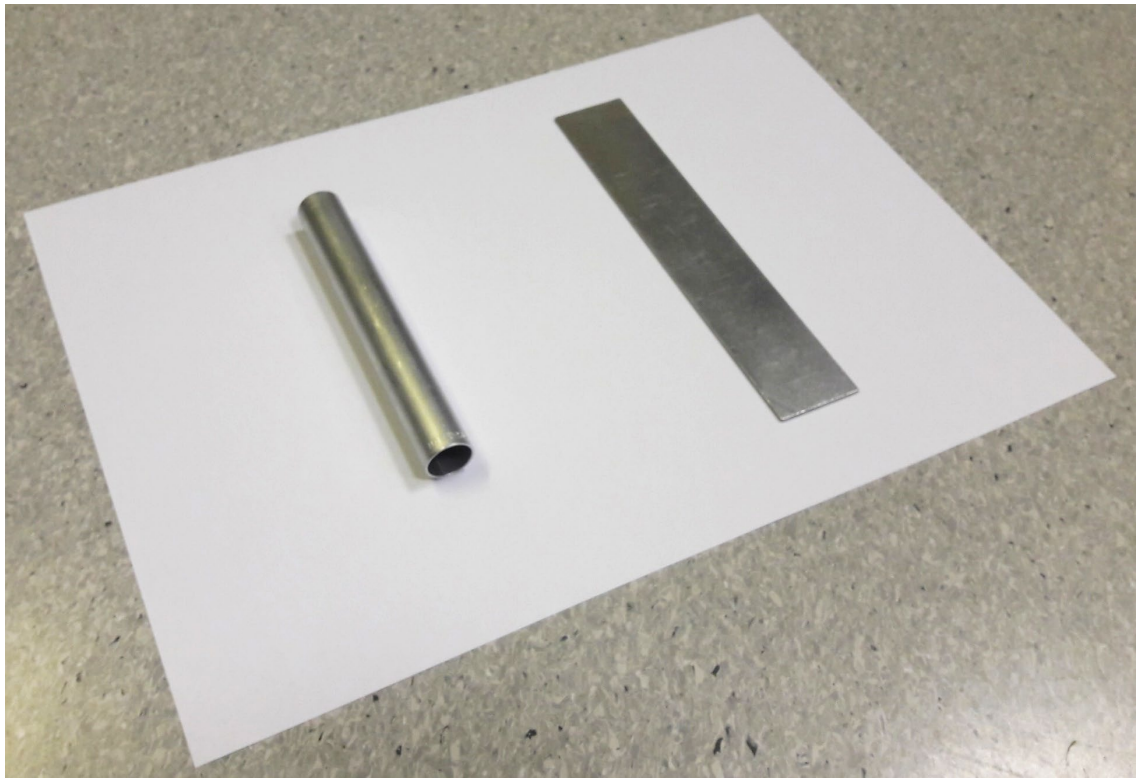
- IRE | IRE Elit group is a Belgian company aiming at promoting the beneficial use of radioisotopes (essentially for medical purposes) through its 3 activities of:
  - Production of radioistopes
  - R&D and production of radiopharmaceutical products
  - Analysis and control of the radioactivity (environment, foodweb,…)
- IRE is a public utility foundation and a major producer of medical radioisotopes on the market since 1971 and accounts currently for: ~25% of ^{99}Mo supply, est. 25-30% of ^{131}I supply, est. 50% ^{133}Xe supply to US market
- IRE was the first MIP to be equipped with the STAX system and make data available

Conversion to LEU

- On March 27th 2023, IRE has dissolved the last HEU target and is now 100% converted to LEU for the production of ^{99}Mo, ^{131}I and ^{133}Xe

- Such a conversion was not simple nor cheap

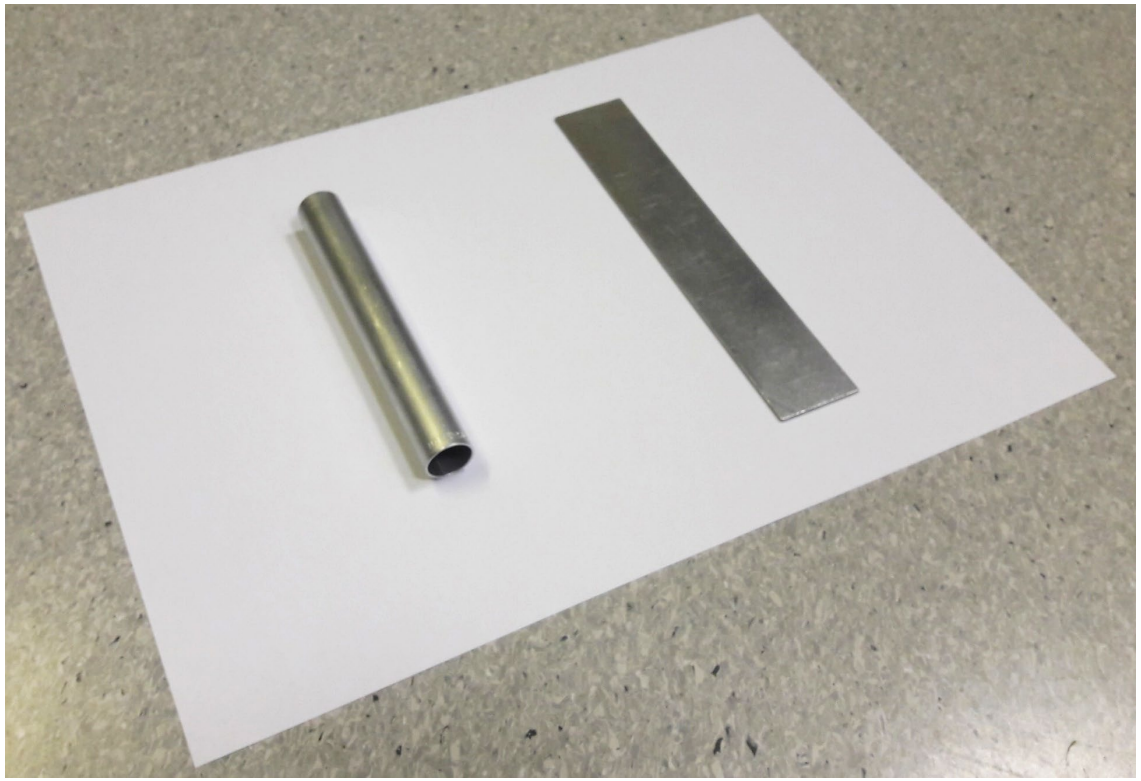
Main process changes: target



- % ^{235}U and shape
  - ↓ fission yield (apparent n^0 flux)
  - Geometrical factors

➔ overall ↓ 20-30% of activity recovered from dissolved target

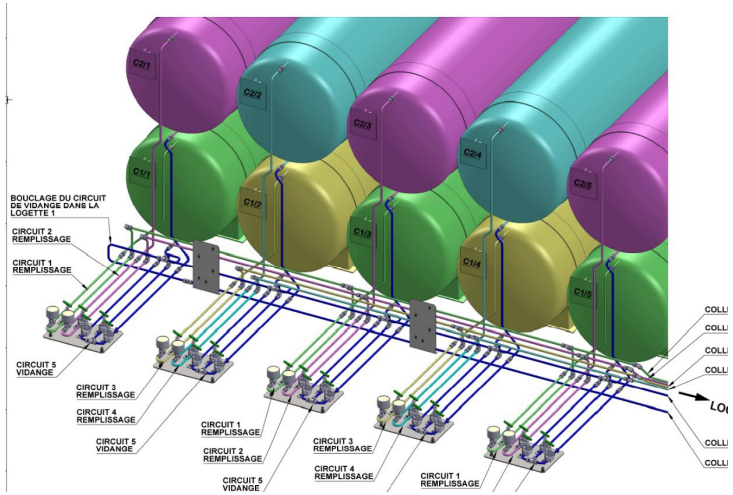
Main process changes: target



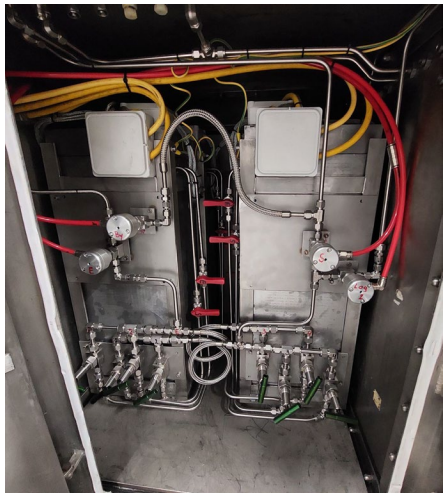
- Al cladding (mass and impurities)
  - ↑ reagents volume and concentration
  - ↑ size of filter and filtration device
  - Change the filter material
  - Additional steps to keep iodine in solution and manage H_2

➔ Overall ↑ of liquid wastes by 10%, fissile material « waste » by 20% (wastes treatment cost by 20%)

Main process changes: others



Decay tanks system

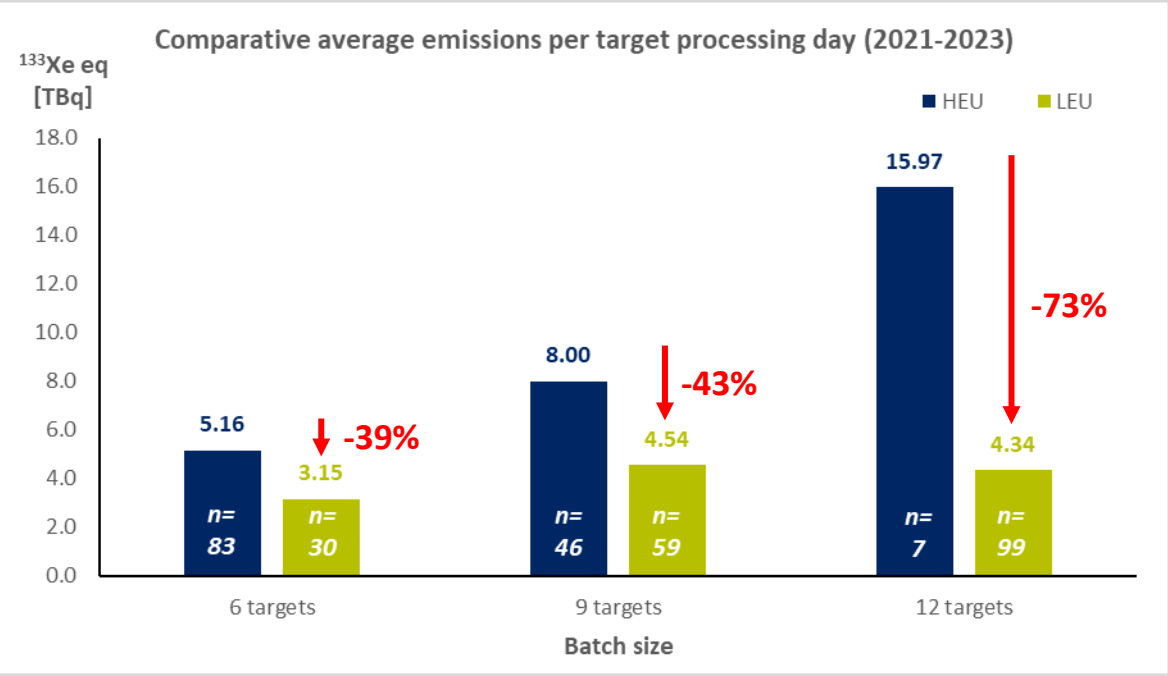


In-line zeolite system

- Process line under atmospheric pressure (additional layer of Defense in Depth)
  - 56 decay tanks connected to the process vessels
- Xe capture at ambient temperature
- ^{131}I separation in alkaline solution

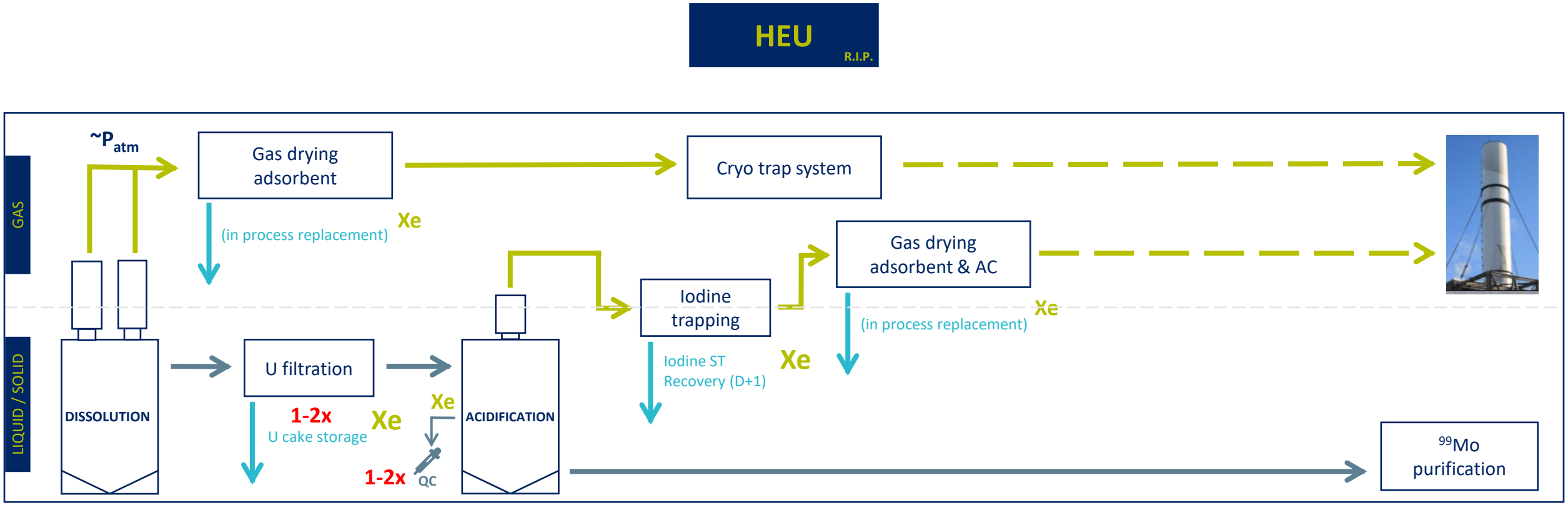
➔ Overall impact on Xe emissions

Comparative ^{133}Xe emissions



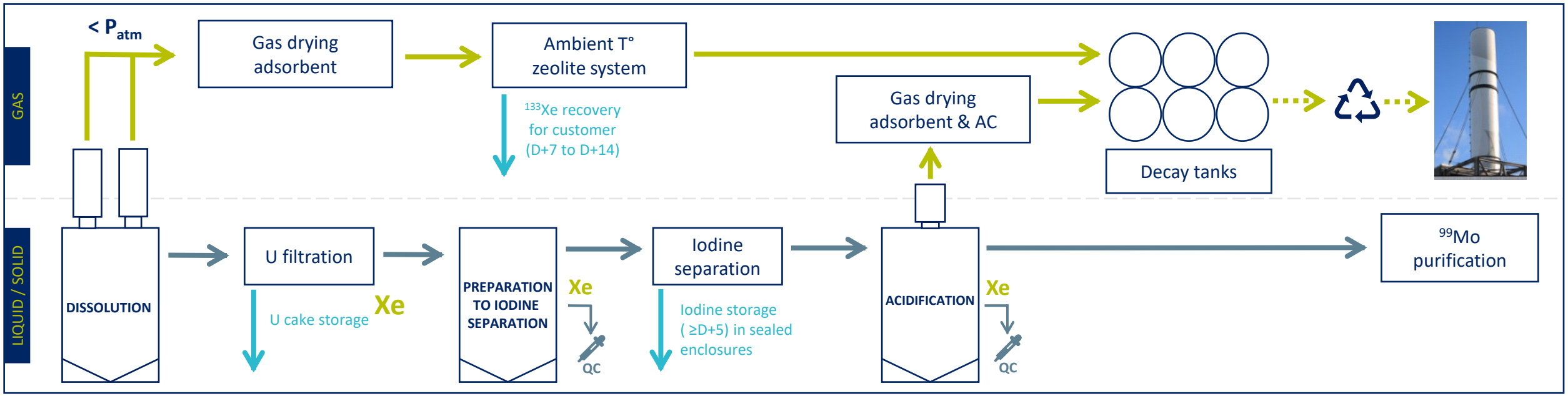
- Dataset:
  - IRE regulatory monitoring
  - 324 target processing days (period: 01 Jan 2021 to 20 Oct 2023)
  - Emissions of ^{133}Xe, ^{133m}Xe, ^{135}Xe and ^{135m}Xe integrated as $^{133}Xe_{eq}$ emissions (weighted sum of activities) – no ^{131m}Xe
- Observation:
  - neat abatement of average $^{133}Xe_{eq}$ emissions with the LEU process
  - larger decrease for larger batch size

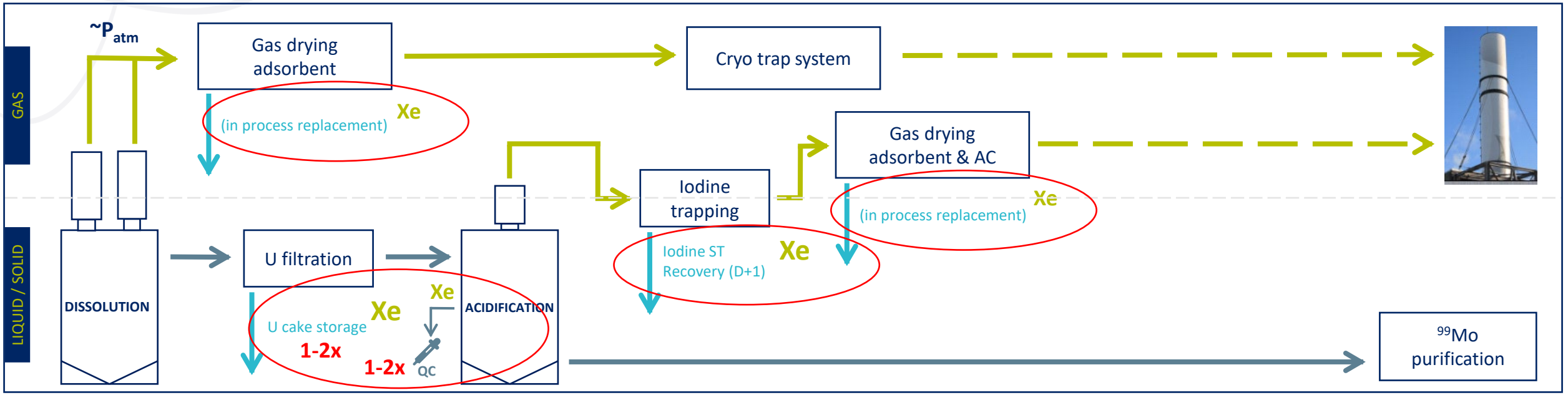
Comparative ^{133}Xe emissions : insights

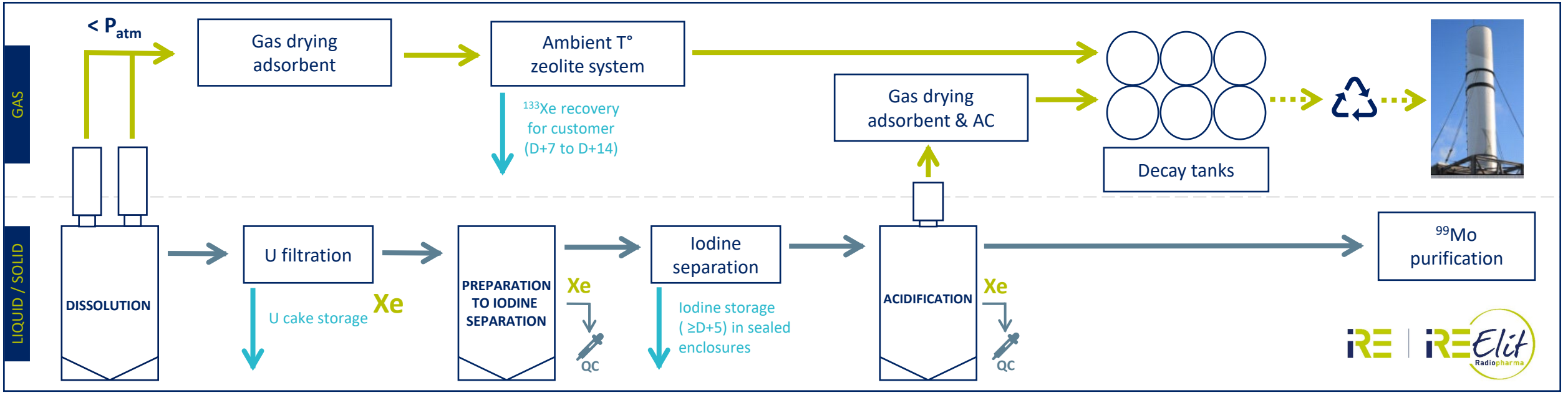


Comparative ^{133}Xe emissions : insights

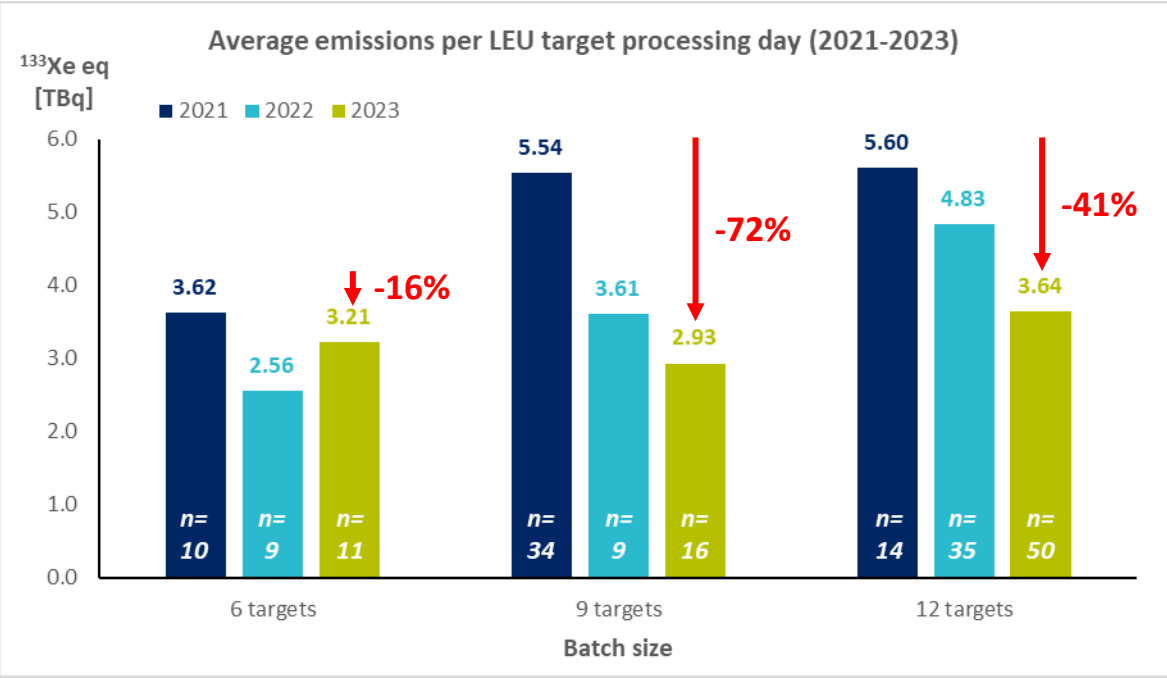
LEU




GAS
LIQUID / SOLID
~P atm
Gas drying adsorbent
Cryo trap system
(in process replacement)
Xe
Iodine trapping
Gas drying adsorbent & AC
Iodine ST Recovery (D+1)
Xe
(in process replacement)
Xe
DISSOLUTION
U filtration
U cake storage
Xe
1-2x
1-2x
QC
Xe
ACIDIFICATION
99Mo purification


GAS
LIQUID / SOLID
< P atm
Gas drying adsorbent
Ambient T° zeolite system
133Xe recovery for customer (D+7 to D+14)
Gas drying adsorbent & AC
Decay tanks
DISSOLUTION
U filtration
U cake storage
Xe
PREPARATION TO IODINE SEPARATION
Xe
QC
Iodine separation
Iodine storage (≥D+5) in sealed enclosures
ACIDIFICATION
Xe
QC
99Mo purification
iRE
iREElit Radiopharma

^{133}Xe emissions with the LEU process



- Overall abatement of emissions thanks to
  - Refining of operators' skills on the process (more in less time)
  - Continuous improvement on:
    - SOPs
    - Equipment design review (enclosures, seals,…)
- Potential improvements at unavoidable opening steps of the process line

Conclusion

- Conversion to LEU involved major changes to the production process with a significant impact on the production costs (especially wastes)
- With the technical modifications implemented (and not thanks to LEU per se), we observed a significant abatement of $^{133}Xe_{eq}$ emissions with the new process, attributable to: unit operations, process line under atmospheric pressure, management of the ^{135}I – ^{133}I – ^{131}I source term
- Progress observed during the LEU ramp-up phase (2021-2023) with a decrease in $^{133}Xe_{eq}$ emissions of up to 72 % for medium batch size and 41% for largest batch size
- IRE is committed towards further reducing its $^{133}Xe_{eq}$ emissions

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