

Nuclear science to benefit society

June 2022

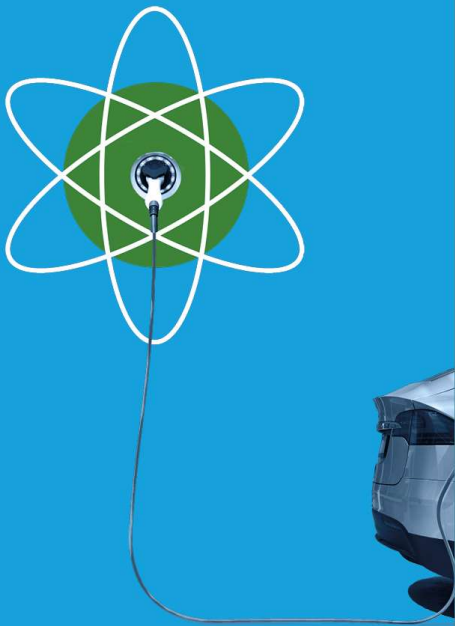
Luke O'Brien

Applying the Waste Hierarchy for Future Recycling of Nuclear Fuels

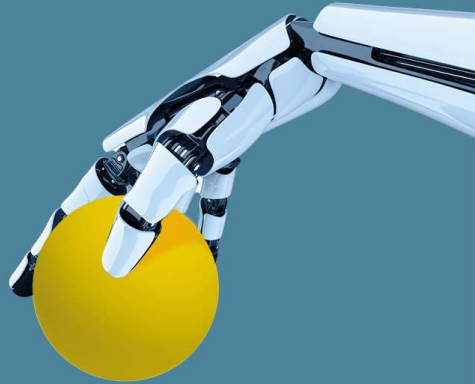
Waste Minimisation

Four Focus Areas

Clean Energy



Environmental Restoration



Health and Nuclear Medicine

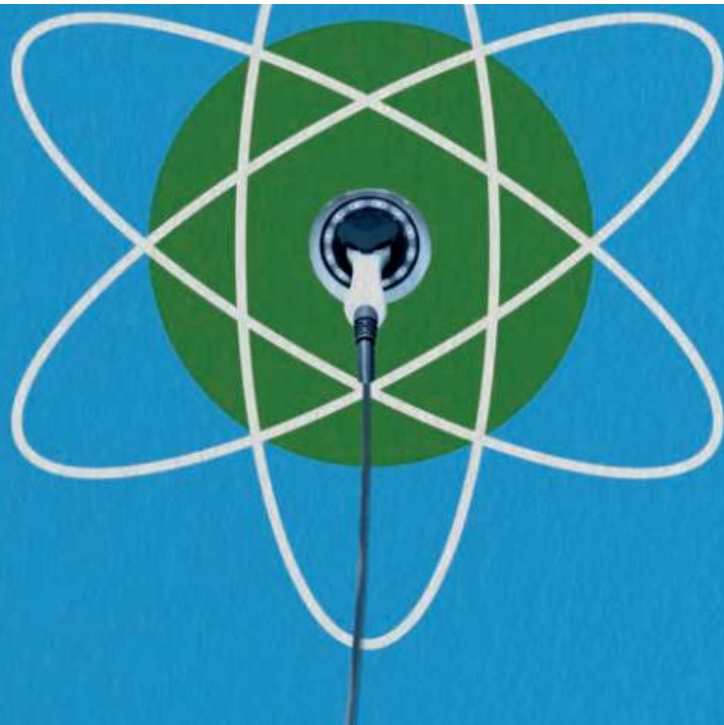


Security and Non-Proliferation



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National Nuclear Laboratory



Clean Energy

A thriving nuclear power sector is an essential component of the UK's path to net zero

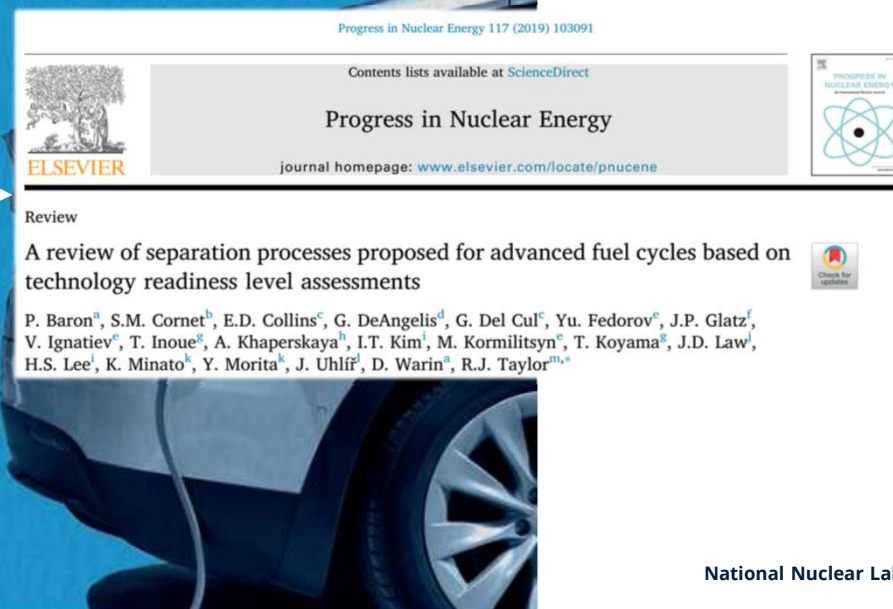
At NNL, sustainability is a core part of the approach

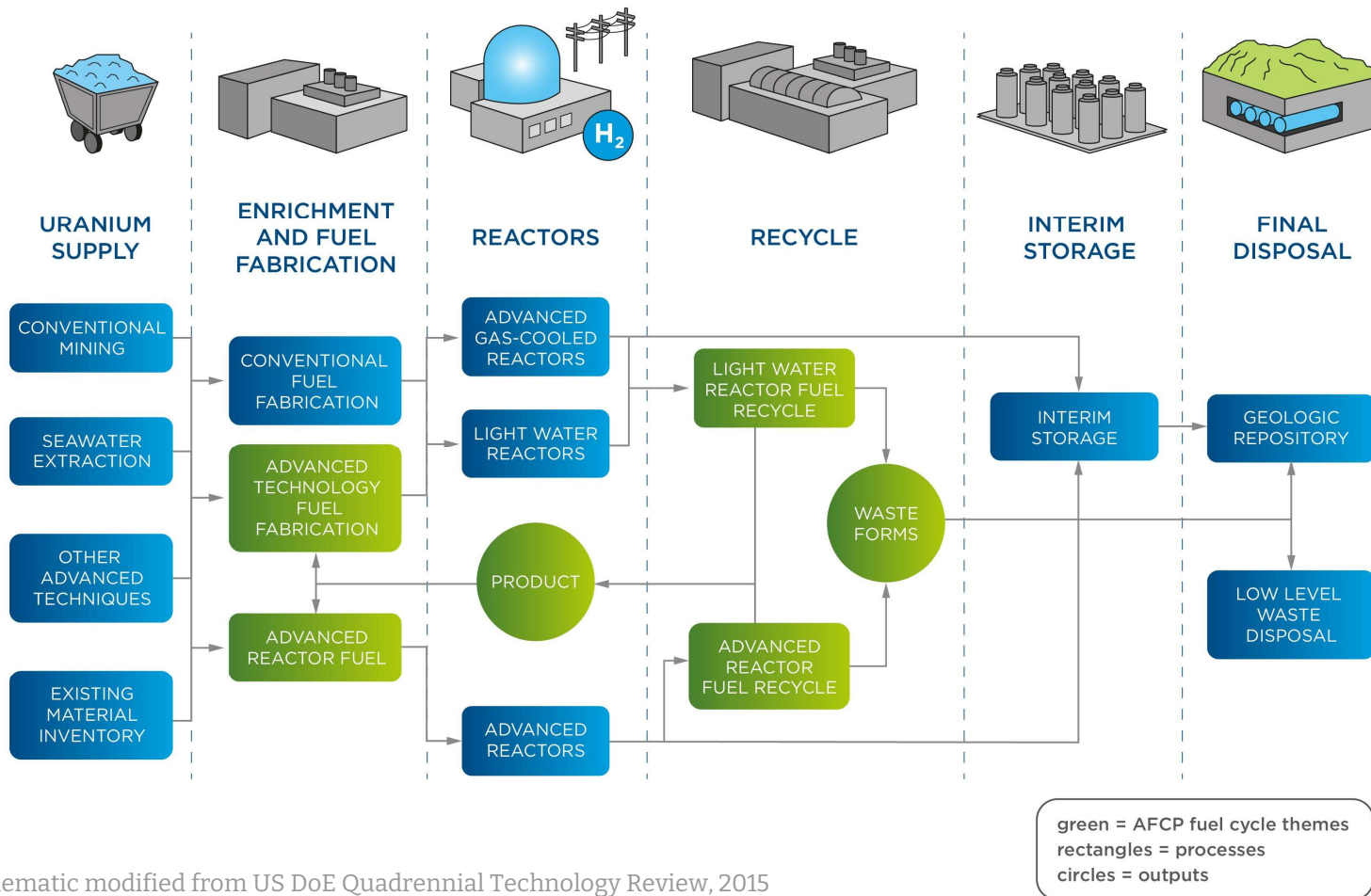
Example:

AFCP
Advanced Fuel Cycle Programme

Future fuel cycle requirement:

“Reduce waste generation and lower environmental impact”





4 of 11 projects specifically involve consideration of waste arisings

Nuclear Fuels

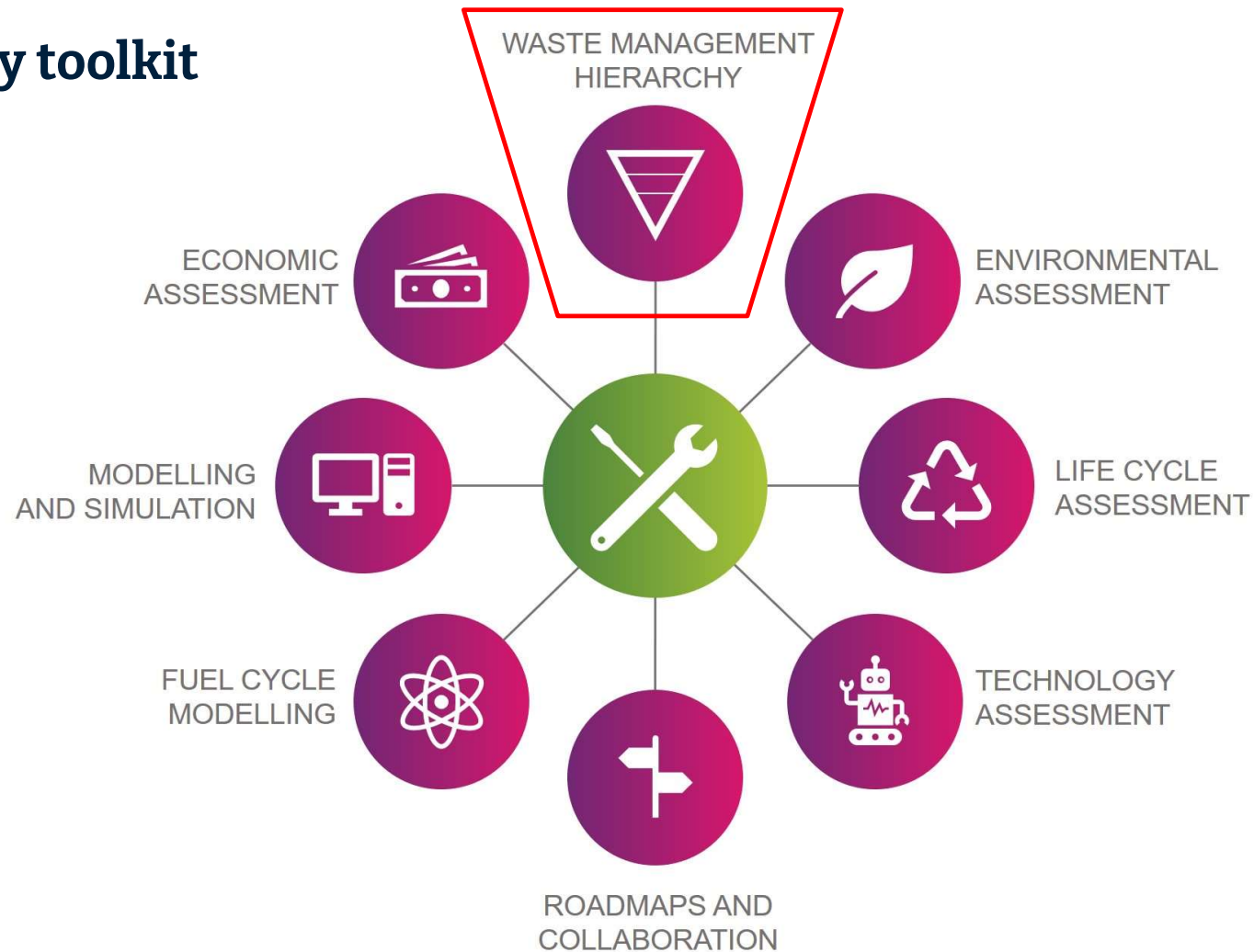
- Coated Particle Fuels
- Fast Reactor Fuels
- Accident Tolerant Fuels
- Nuclear Data

Nuclear Recycle

- Pyroprocessing
- Fast Reactor Fuel Recycle
- Aqueous Recycle
- Processing Aqueous Wastes
- Off-gas Capture
- Solvent & Effluent treatment
- Pyroprocessing wastes

Schematic modified from US DoE Quadrennial Technology Review, 2015

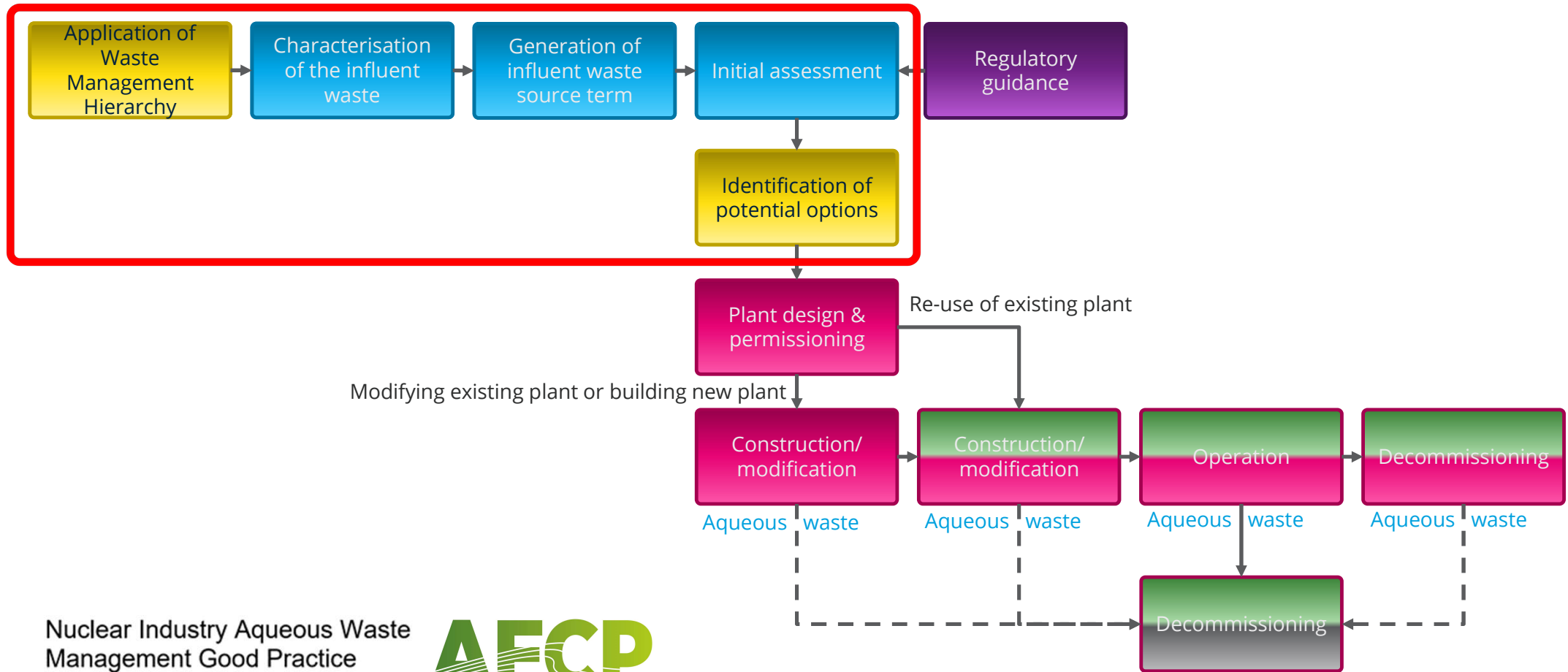
Sustainability toolkit



J. Turner, J. Spencer, L. O'Brien, S. J. Palethorpe, A. Banford, and R. Taylor, 'Applying the Waste Hierarchy for Future Recycling of Nuclear Fuels', *Nuclear Future*, vol. 17, no. 6, pp. 43–50, Dec. 2021.

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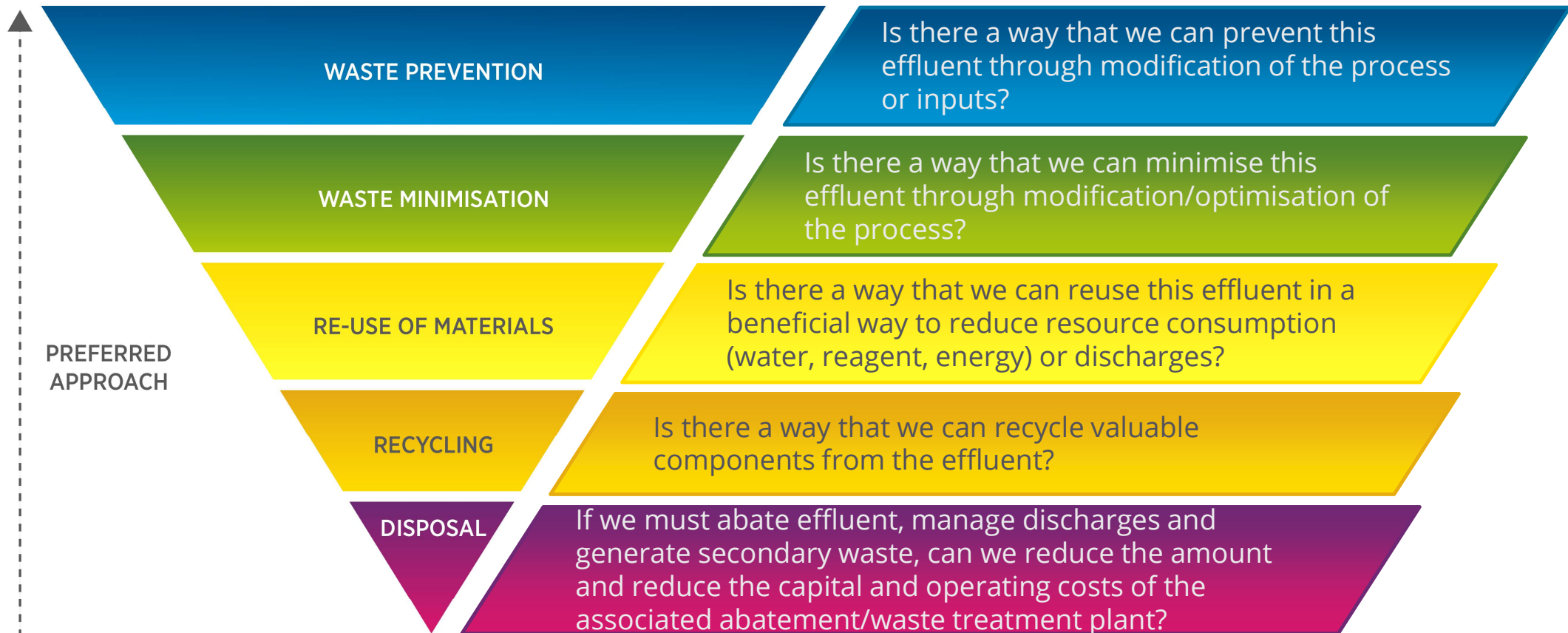
Background



Nuclear Industry Aqueous Waste
Management Good Practice
Guidance

AFCP
Advanced Fuel Cycle
Programme

Process



J. Turner, J. Spencer, L. O'Brien, S. J. Palethorpe, A. Banford, and R. Taylor, 'Applying the Waste Hierarchy for Future Recycling of Nuclear Fuels', *Nuclear Future*, vol. 17, no. 6, pp. 43–50, Dec. 2021.

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Process – Where to start?

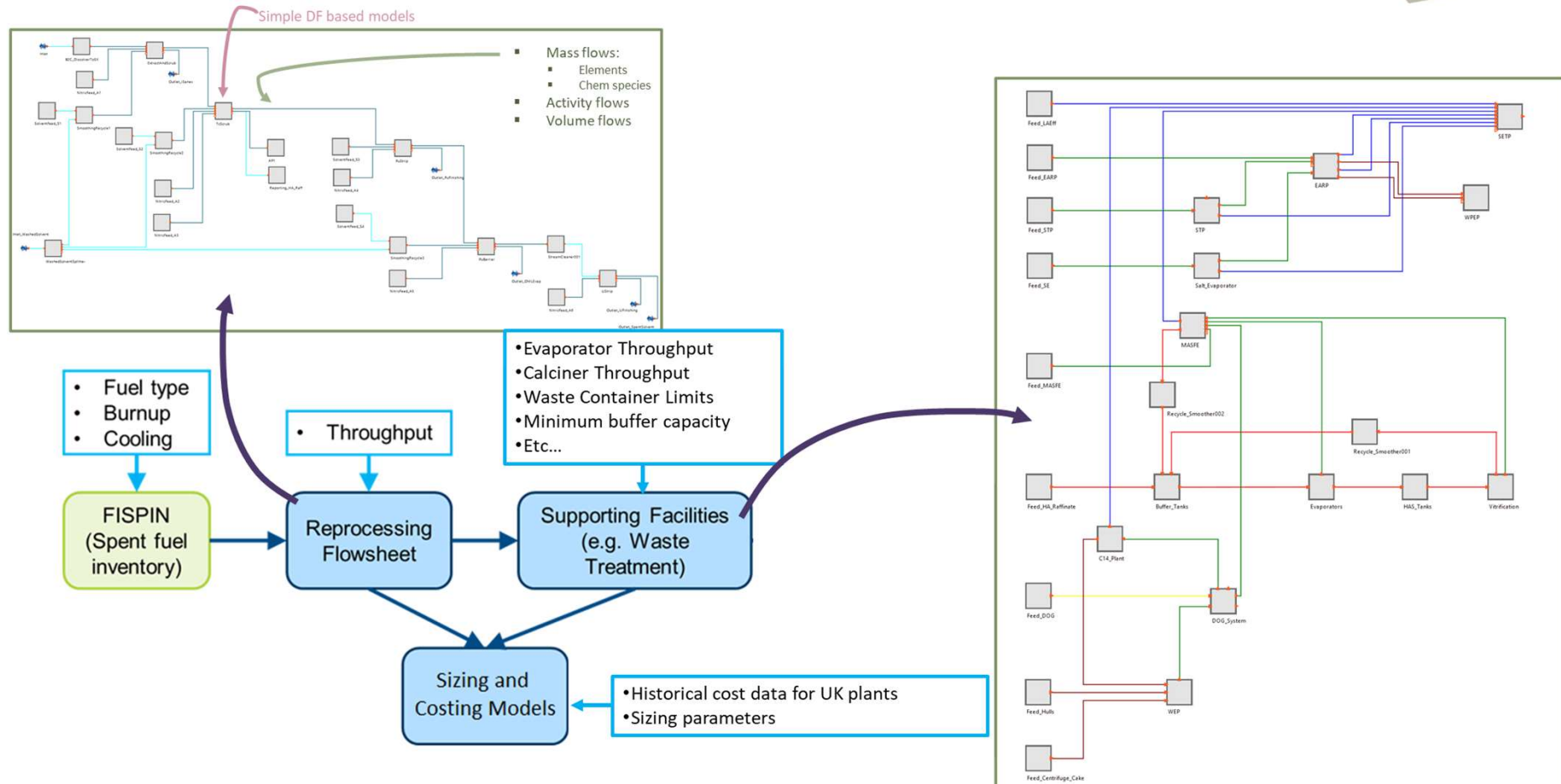
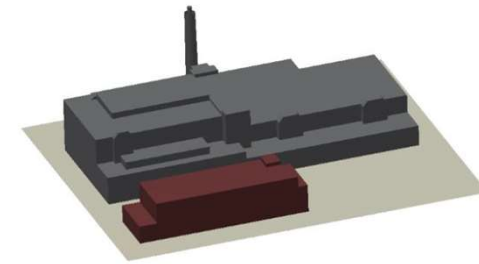
- Use expertise already in the laboratory, gained from supporting current generation reprocessing plants
 - > 400 person year experience
 - Opportunity to train the next generation
-
- Understand our baseline process
 - Apply the waste management hierarchy
 - Identify solutions

From this over 50 opportunities were identified



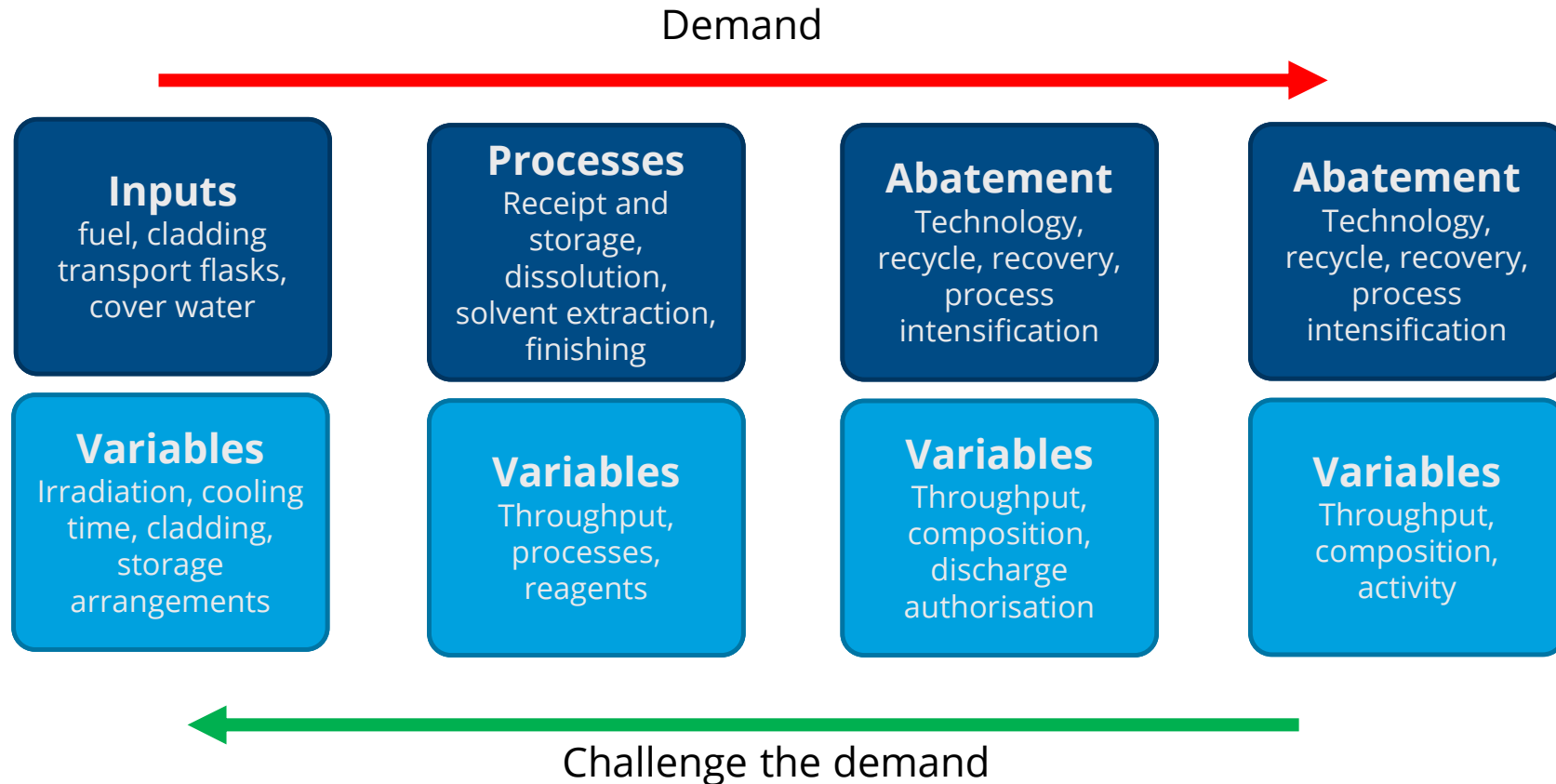
Process – Sim Plant and the power of modelling

- What is Sim Plant?
- gProms model of a recycle plant, based around decontamination factors
- Supporting facilities initially based off of **Thorp**

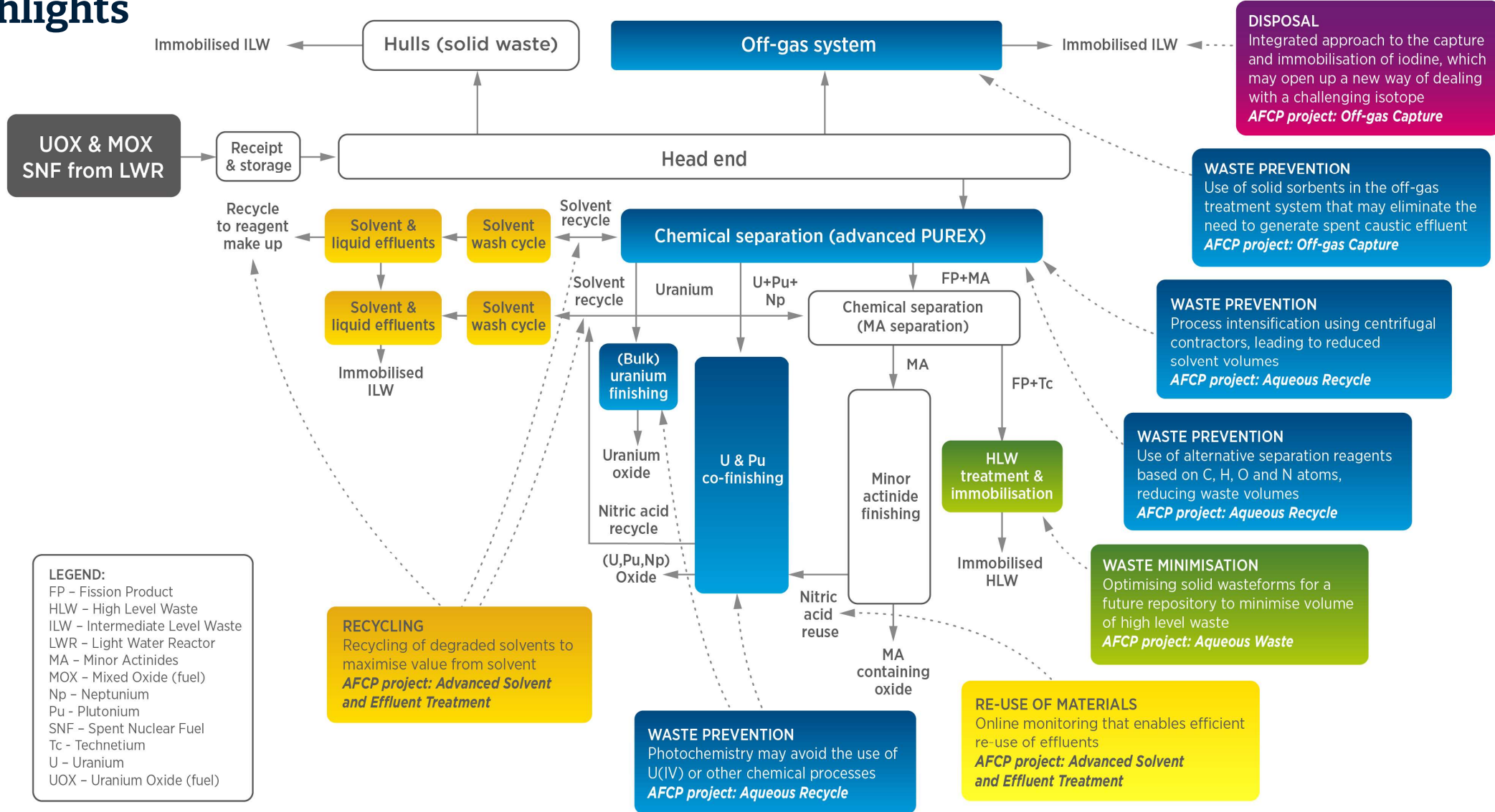


Process

- Enables life cycle consideration
- Upstream changes can lead to lower waste demand



Highlights



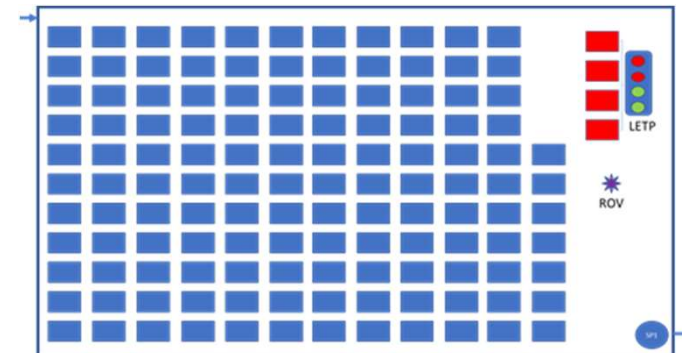
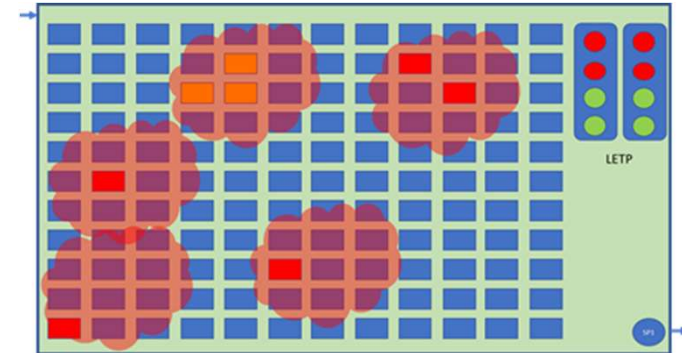
Highlights

Prevention

- Develop 'dry' fuel shear
- Eliminate off-gas scrubber effluent (treat and solidify)
- Eliminate solvent wash liquor (absorbents)
- Eliminate steam strip (different evaporation approach)

Minimisation

- Significant reduction in treatment volume/day (smart skips)
- PI opportunities in upstream processes (further reduce volume burden)
- Chemical burden
- Significant Na reduction through process modification
- Enable re-routing of effluent through common technology with no waste burden



Highlights: Re-use and recycle



Recycling

- Electrodeposition and reuse of catalysts
- Recovery of critical resources (Platinum group metals)

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Re-use of materials

Re-use reagent

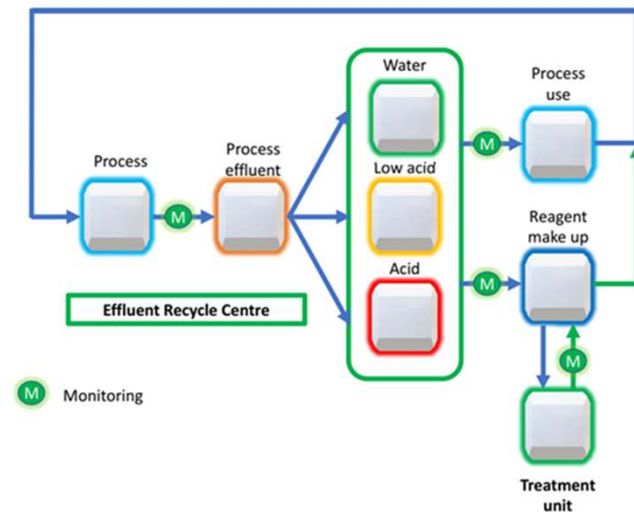
- Near complete recycle of nitric acid
- Extensive recycle of solvent (up to 60 times)
- Other reagents identified for recycle

Re-use water

- Significant volume/day identified to be re-used
- Concept effluent recycle centre developed

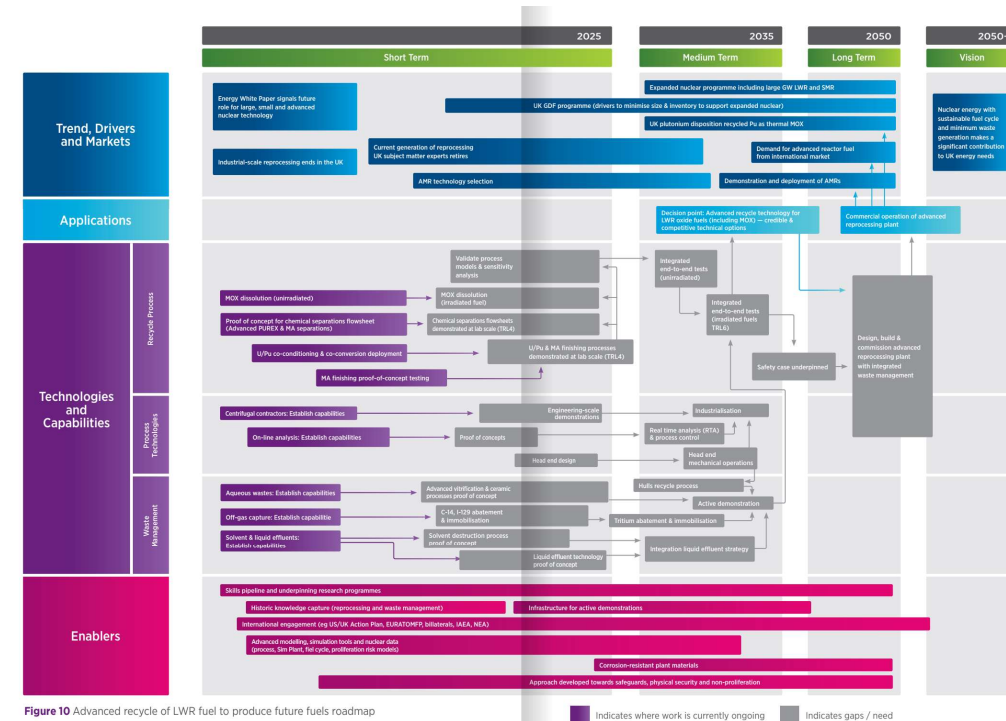
Re-use of process heat

- 50% reduction in energy usage
- 80% reduction in process water usage



Conclusions

- Identified >>50 opportunities to improve source term
- Using our sustainability toolkit to understand challenges and develop solutions
- Significant knowledge transfer and development of early career workers
- Opportunity for established experts to reflect on:
 - Historic design decisions
 - Technology developments
 - Challenges to realise opportunities understood e.g. Monitoring & supplementary treatment requirement



Acknowledgements

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Thank you

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