BQE Water

Commissioning and Ramp-up of SART and Selen-IX:

Key Ingredients to Achieving McNulty Series 1 or Better

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McNulty Criteria

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1) Novelty and complexity of process

2) Sophistication and capability of project team





Novel Process - SART

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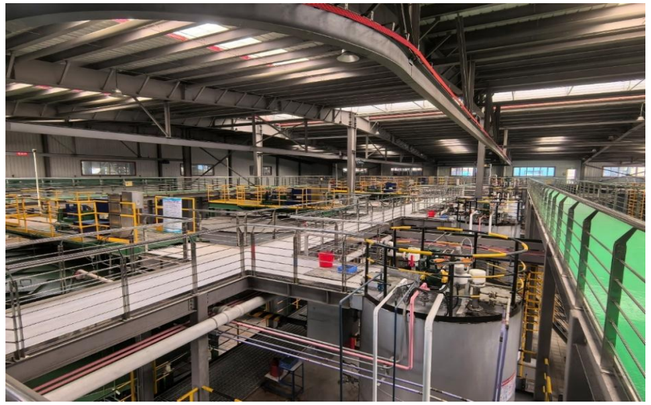
Inventor: Chris Fleming (SGS Lakefield) - 1998

Goal: Recovery and recycle of cyanide consumed by base metals with concurrent recovery of base metals into high grade concentrates



Relevance: Enable exploitation of precious metals deposits rich in cyanide soluble copper and zinc.

State of Technology Adoption prior to 2020: 9 industrial plants built globally, 0 plants in US and Canada

BQE Water's Role: Technology enabler (prior expertise in selective metal recovery using H_2S). Design/Commissioning/Operations Support by BQE Water in 4 of these plants

3 SART Plants Case studies between 2020 and 2025 – Zhongkuang, Zhaojin, Shandong Gold

Novel Processes – Selen-IX

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Inventor: BQE Water (US and CAN patents - 2013)

Goal: Selenate removal below 2 ppb, no new constituents released into treated water, stable residue suitable for re-use.

Relevance: Environmental compliance without reliance on dilution, zero risks of chronic effects in aquatic environment, enabling intermittent and seasonal operations, no long-term liability with selenium residue.

State of Technology Adoption prior to 2020: 0 industrial plants.

BQE Water's Role: Inventor-developer

2 Case Studies – Kemess and Hermosa



SART & Selen-IX – Common Attributes

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1) **Disruptive technologies with origin outside of major mining houses or equipment suppliers.**

2) **New chemical processing schemes contrary to status quo knowledge**
   - ❑ SART into metallurgical processing
     - ❑ avoidance of Cu in Au ores
     - ❑ operating cyanide at low pH / HCN emissions
     - ❑ uses hydrogen sulphide at low pH
   - ❑ Selen-IX into water management previously 100% reliant on biological approaches.
     - ❑ Biological reduction identified as the Best Available Technology (BAT) in 2012
     - ❑ Selenium electro-reduction process in electrocells unknown

3) **Limited prior installations – expertise concentrated with developer/enabler**

4) **Key to sustainability – expected increase in adoption**

McNulty Criteria

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SART Results | Hydraulic Capacity

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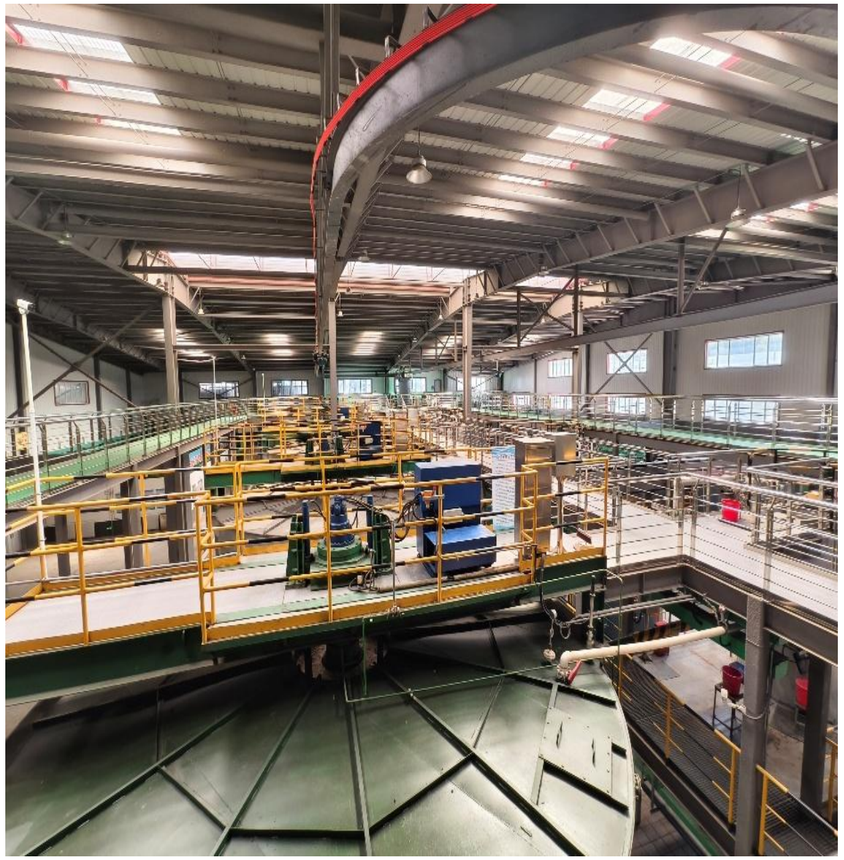

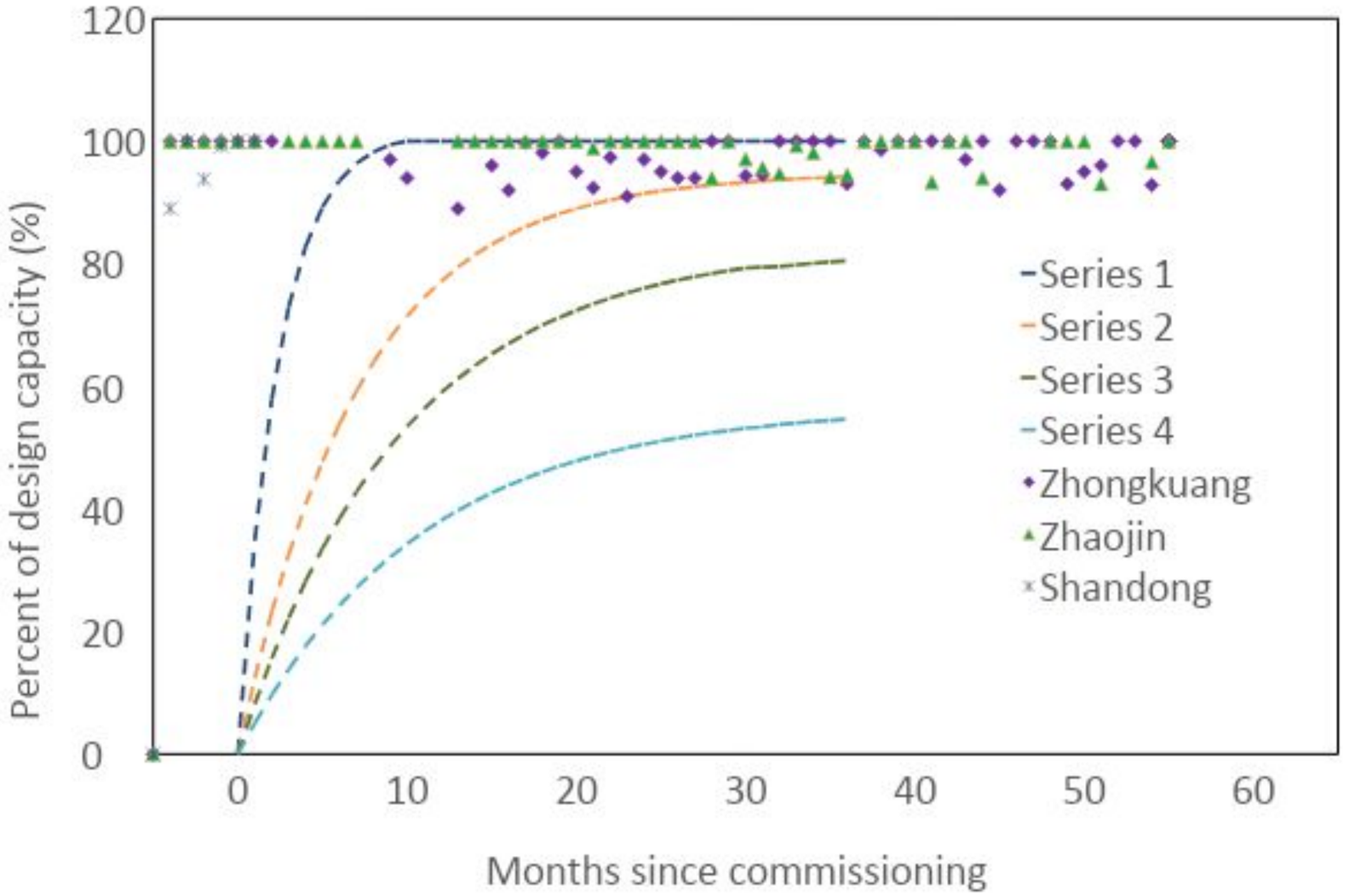

SART Results | Copper Removal

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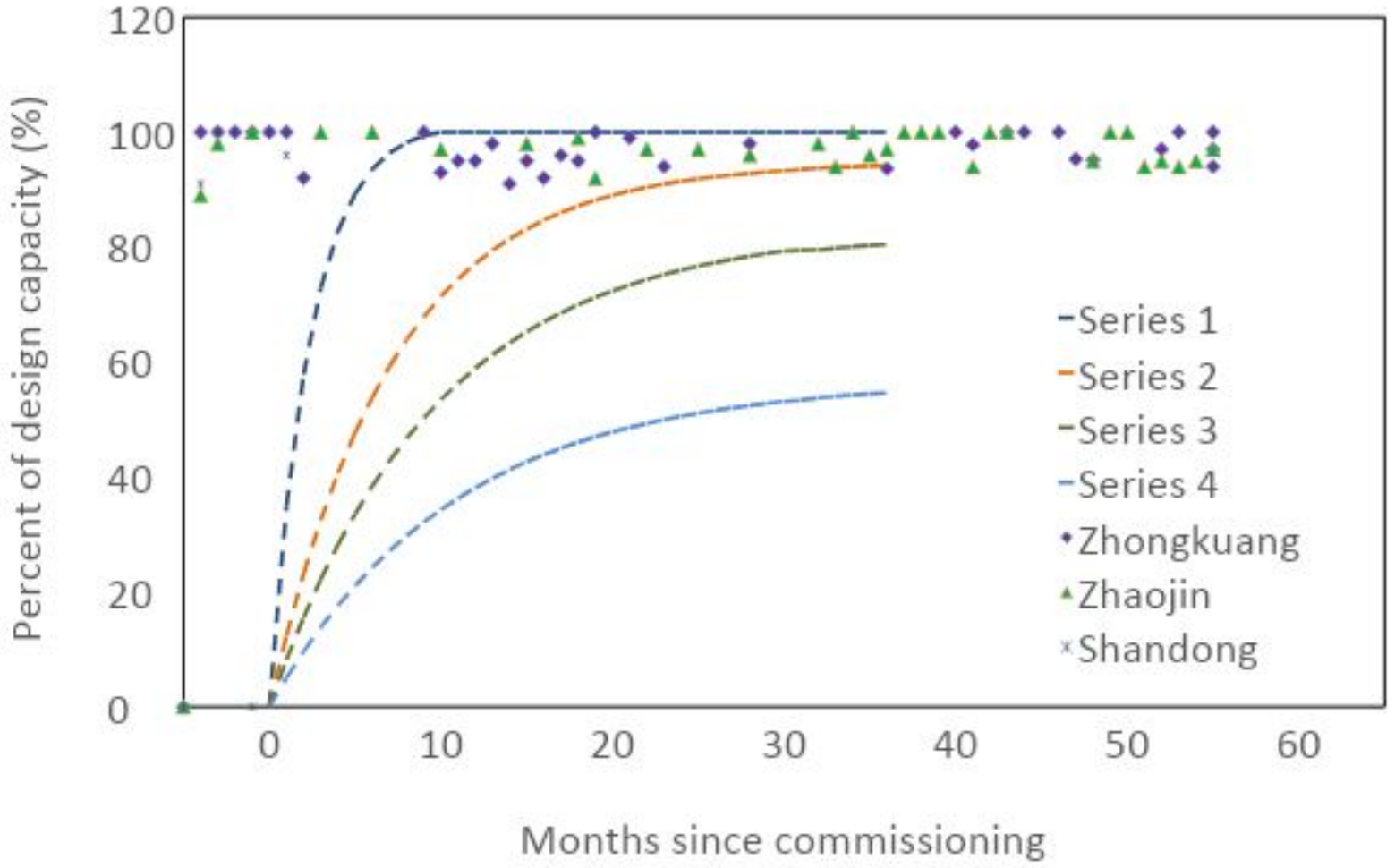

Shandong Gold SART Performance

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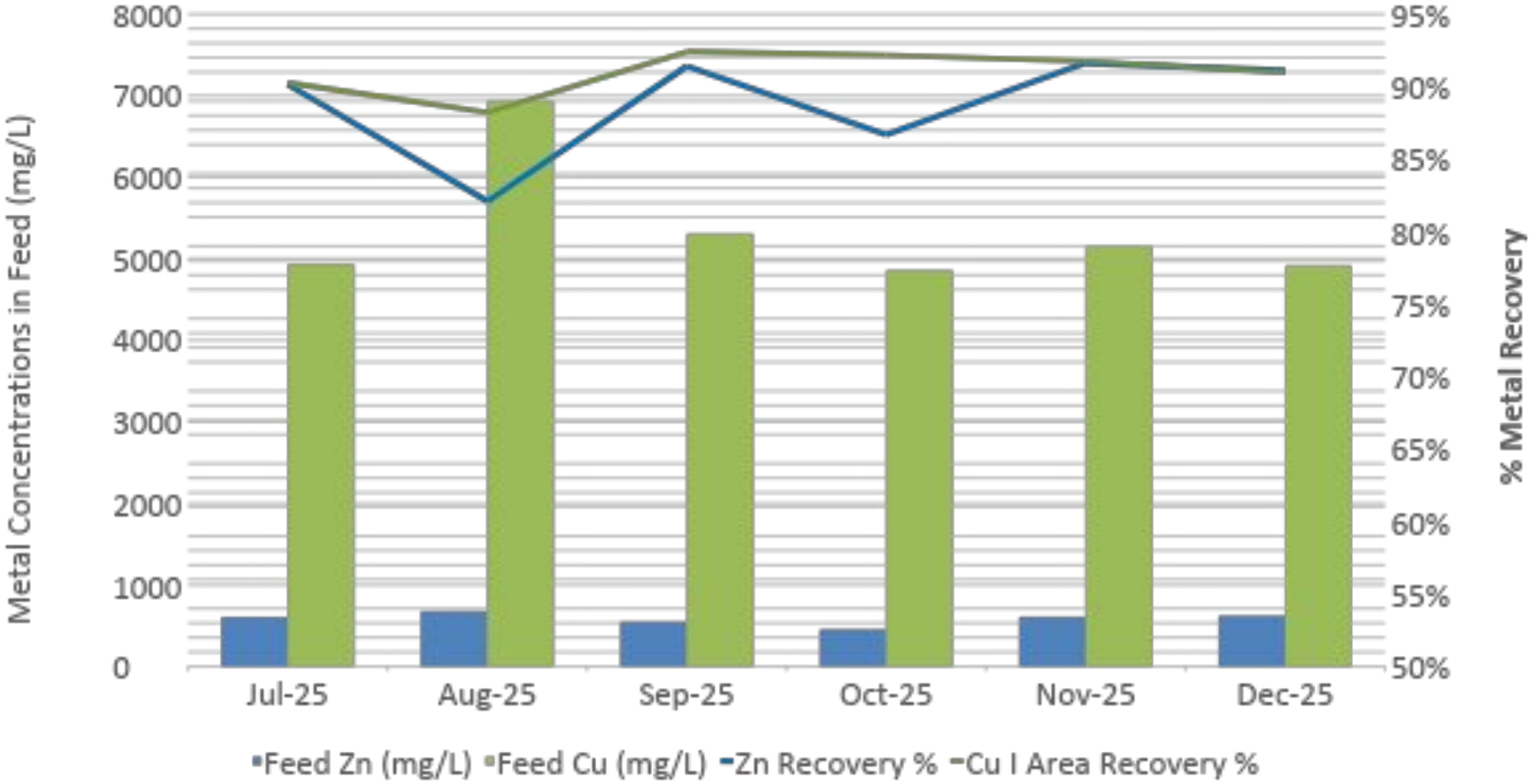

Shandong Gold SART Concentrates

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Copper Concentrate

Zinc Concentrate

SART Results | EH&S

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SART Plant	Years in Operations since Commissioning Completion	Number of E&HS Incidents		Environmental Incident Description	Health Safety Incident Description
		Commissioning	Operations		
Zhongkuang	5.5	0	3	Fresh water spray from loose flush port connection caused electrical damage	- Fall/ankle injury - Improper hand tool use/hand injury
Zhaojin	5	0	5	H_2S > 10 ppmV during scrubber media change in dry scrubber ~ 10L of 98% H_2SO_4 leaked from metering pump due to loose connection	- Three hand/finger injuries during maintenance activities
Shandong	< 1	0	0	No incidents	No incidents

Selen-IX Results | Hydraulic Capacity

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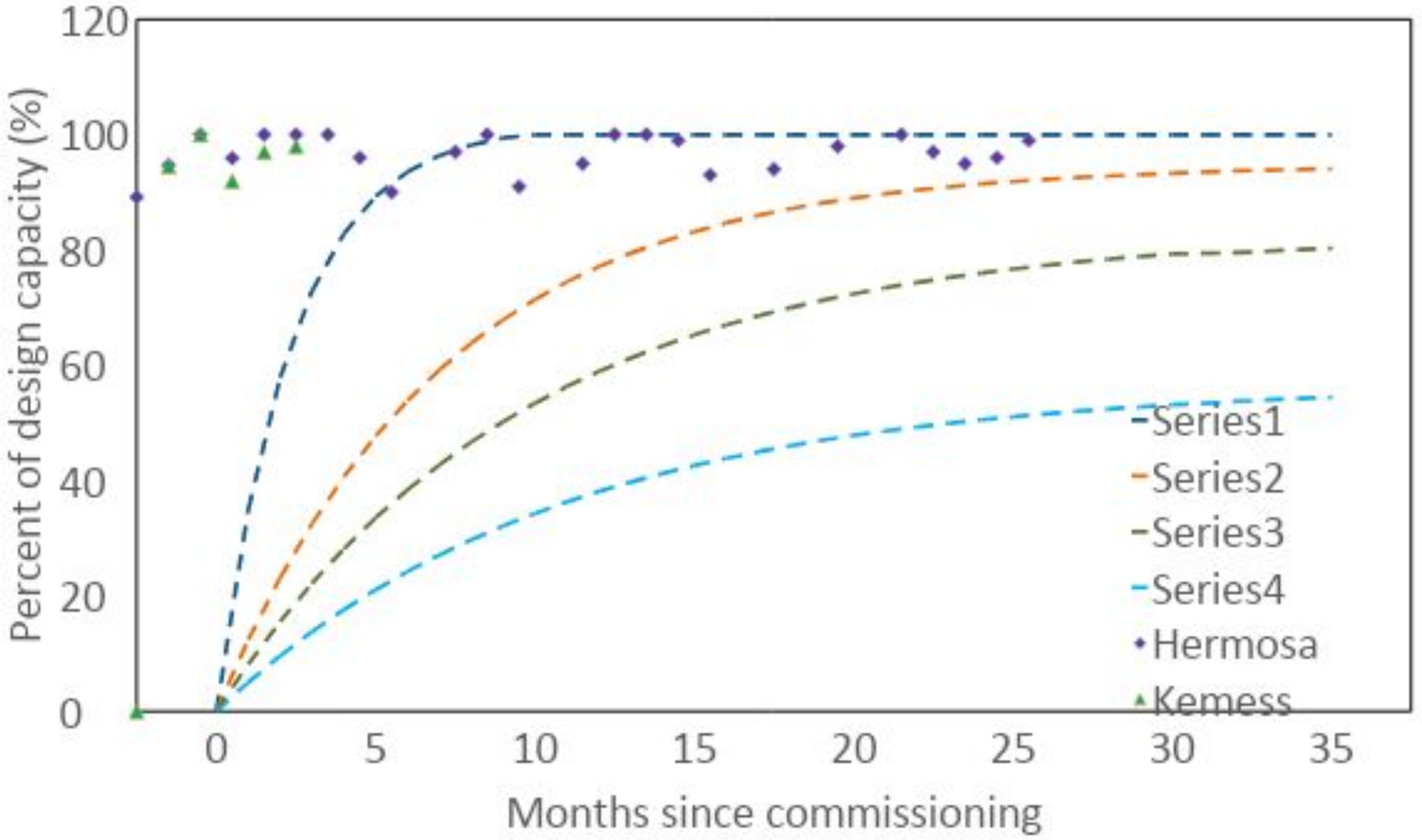

Selen-IX Effluent Quality

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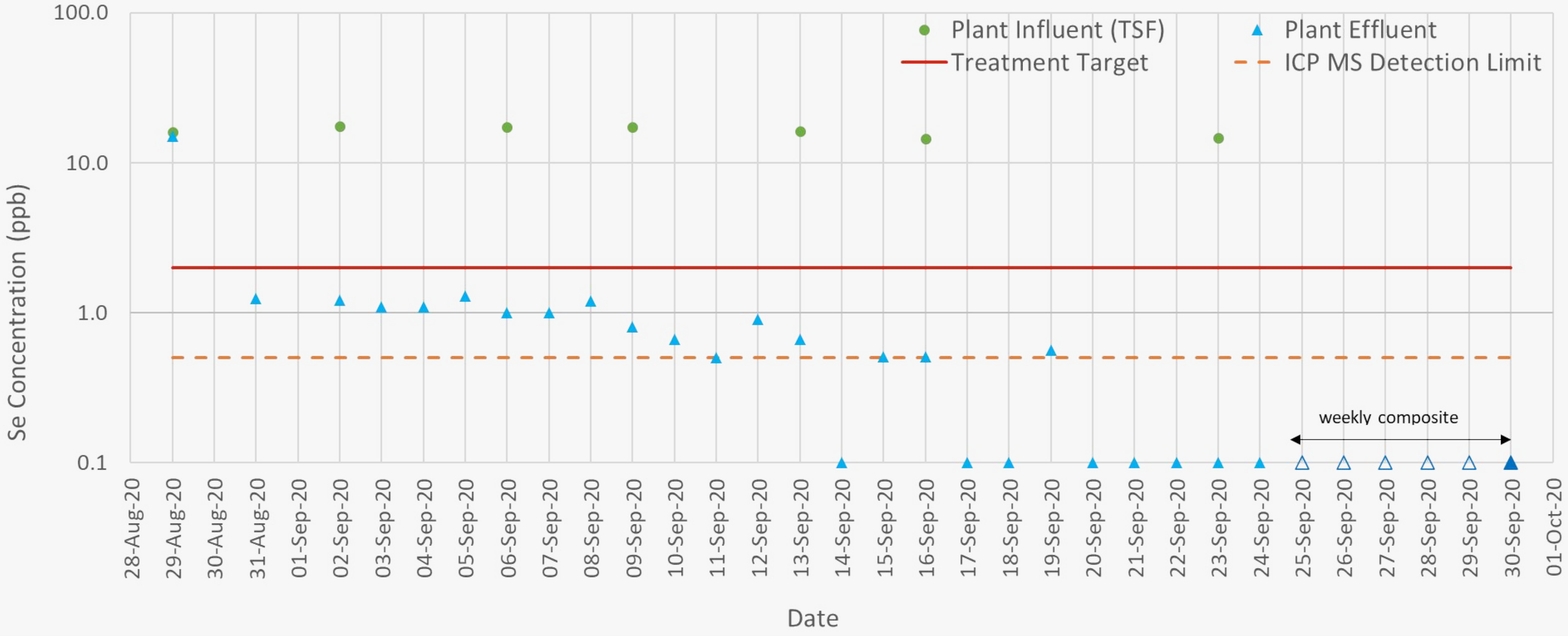

What stands out as being “different”

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- Process expert was accountable not only for process design but for all aspects of engineering, automation, equipment selection, commissioning, and operation of new plants.
  - → Single point of accountability - minimizes interfaces & increases transparency
- Operations services fees were at risk subject to plant performance and were several times greater than engineering and commissioning fees.
  - → Incentives set up to align interests between services provider and project owner
- All professional services related from initial lab testing to operation were sole sourced.
  - → Promotes partnership instead of transactional relationship
- Process expert was allowed to develop a bench depth.
  - → Service provider’s growth was seen as positive for the project owner

In-house Mix of Core Competencies De-risk Projects

Automation



Engineering



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Operation & Commissioning



Process Lab Testing Team

Ability to Deliver in Global Industry

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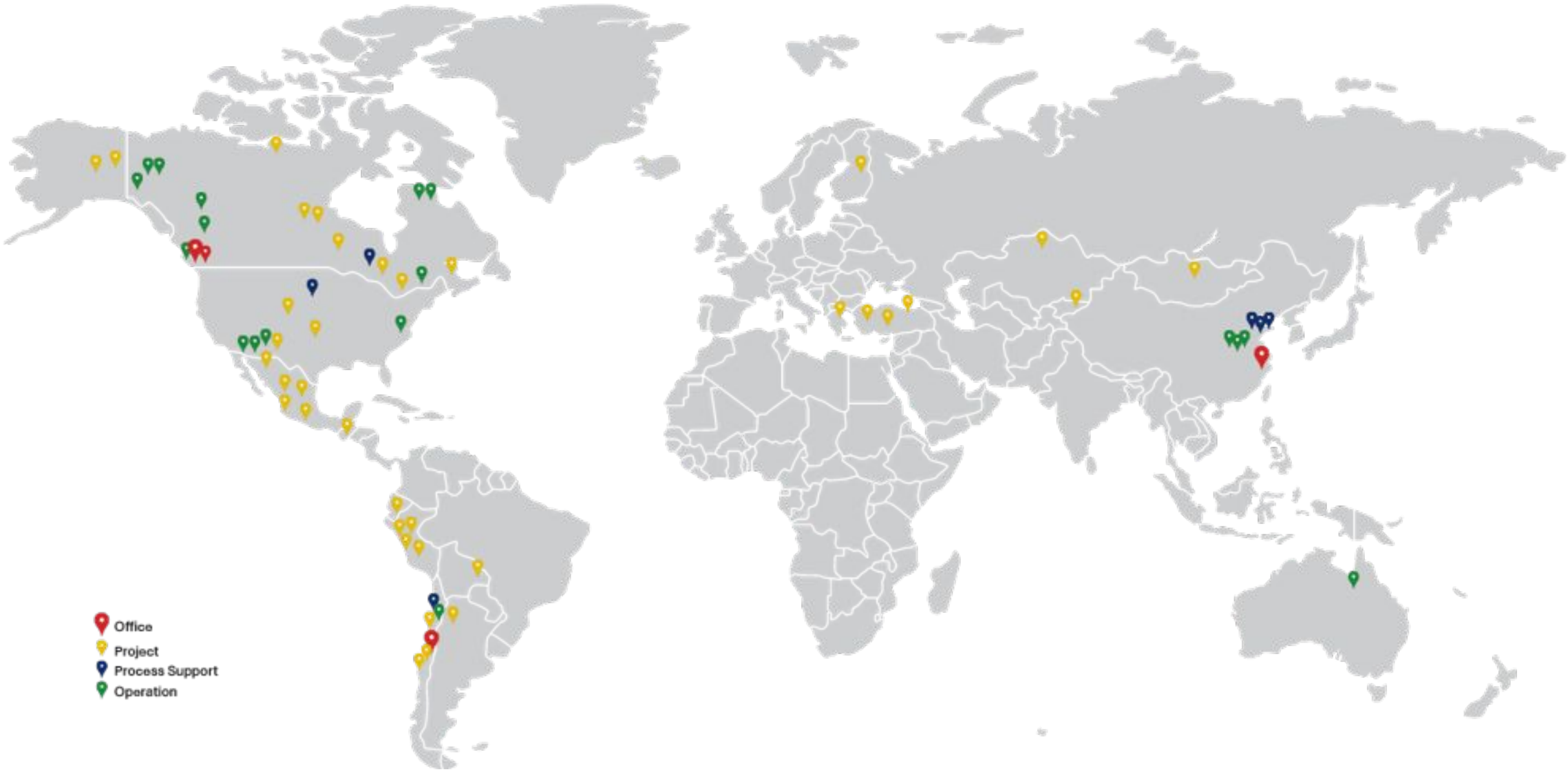

Lessons Learned

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- **Innovators** to invest in building **core competencies outside of process expertise**:
  - automation, commissioning, and operations.

- **Project owners** to consider project execution model holistically.
  - **Sole sourcing** may lead to better outcomes than traditional bidding;
  - **Outsourcing of operations** to experienced process expert can reduce costs and risks. Value generated by achieving McNulty Series 1 or better compared to the alternative should be assessed as part of project execution planning.

- **Project owners and financiers** to recognize that project execution model, **incentives, and risk allocation within the team** could be much stronger predictors of performance than novelty of process or knowledge and skills of individual parties.

Recommendations

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Expand Original McNulty Analysis to Include:

- ❑ Role of process experts in projects deploying novel processes.
- ❑ Project execution model.
  - ❖ Competitive bids vs partnerships.
  - ❖ Allocation of risks.
  - ❖ Incentives.

