EVOLUTION OF TUBE DIGESTION FOR ALUMINA REFINING

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Hatch Associates

Presented by: Brady Haneman

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Bio Data

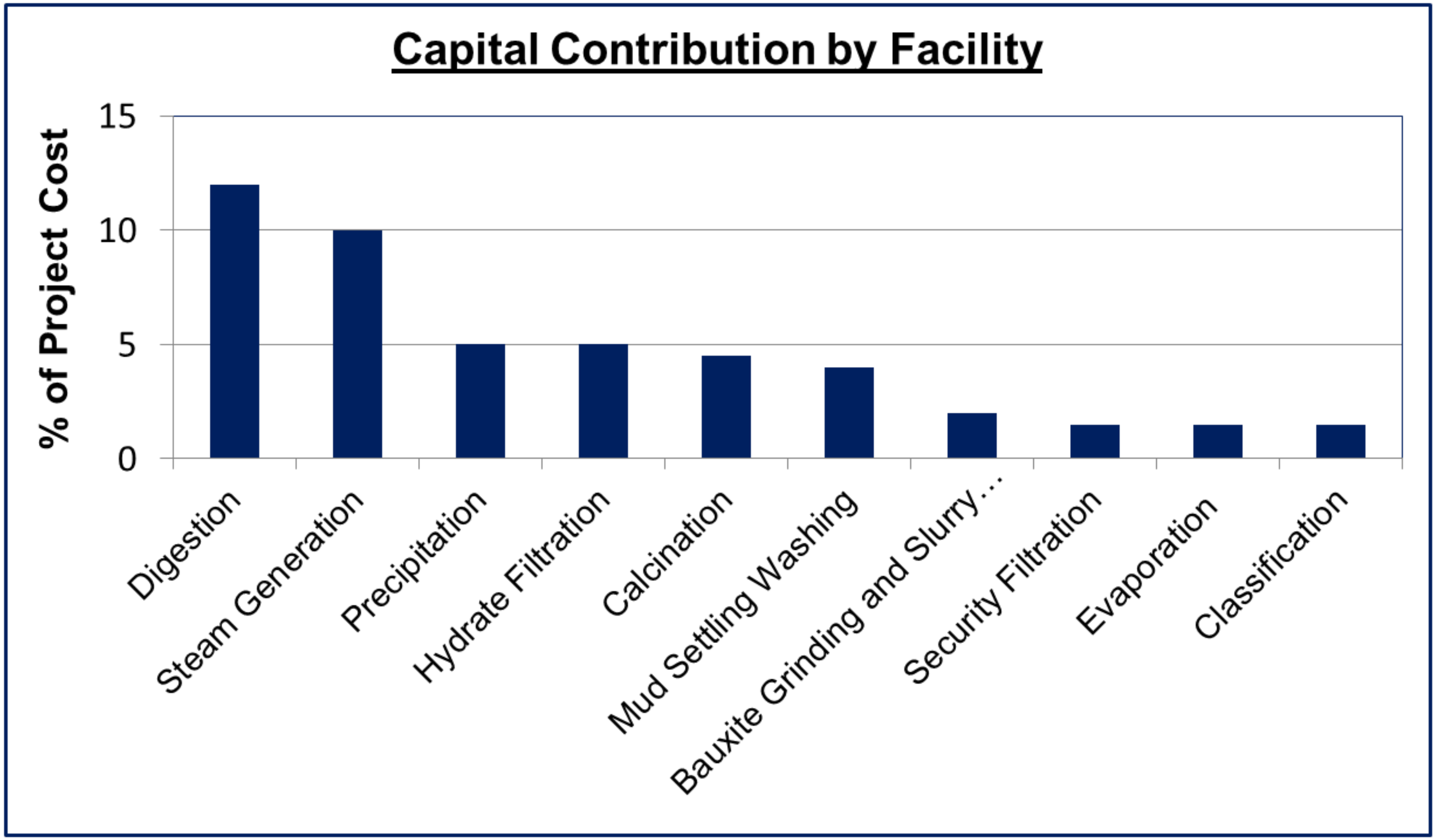
- **Name:** Brady Haneman
- **Degrees:** BE (Chem) Hons, Sydney University Australia
- **Affiliation:** Hatch Associates.
- **Present position:** Director Light Metals – Bauxite & Alumina,
- **Work experience:**
- Brady has over 20 yrs experience in the alumina refining industry covering process operations, feasibility studies, development of new process technologies, plant and equipment design, engineering management and project execution.
- Brady has spent the last 17 yrs on the feasibility and subsequent detailed engineering and commissioning phases of major projects and has been personally responsible for the design of high temperature and low temperature digestion units totalling 9.0 MTpa alumina refining capacity. These refinery projects have incorporated Tube Digestion, Double Digestion and Hybrid Tube Digestion flow sheets. Brady has also consulted to refineries in Australia, Brazil, Ireland, Italy, Ukraine, Saudi Arabia and the U.S. on improvements for their facilities.

Contents

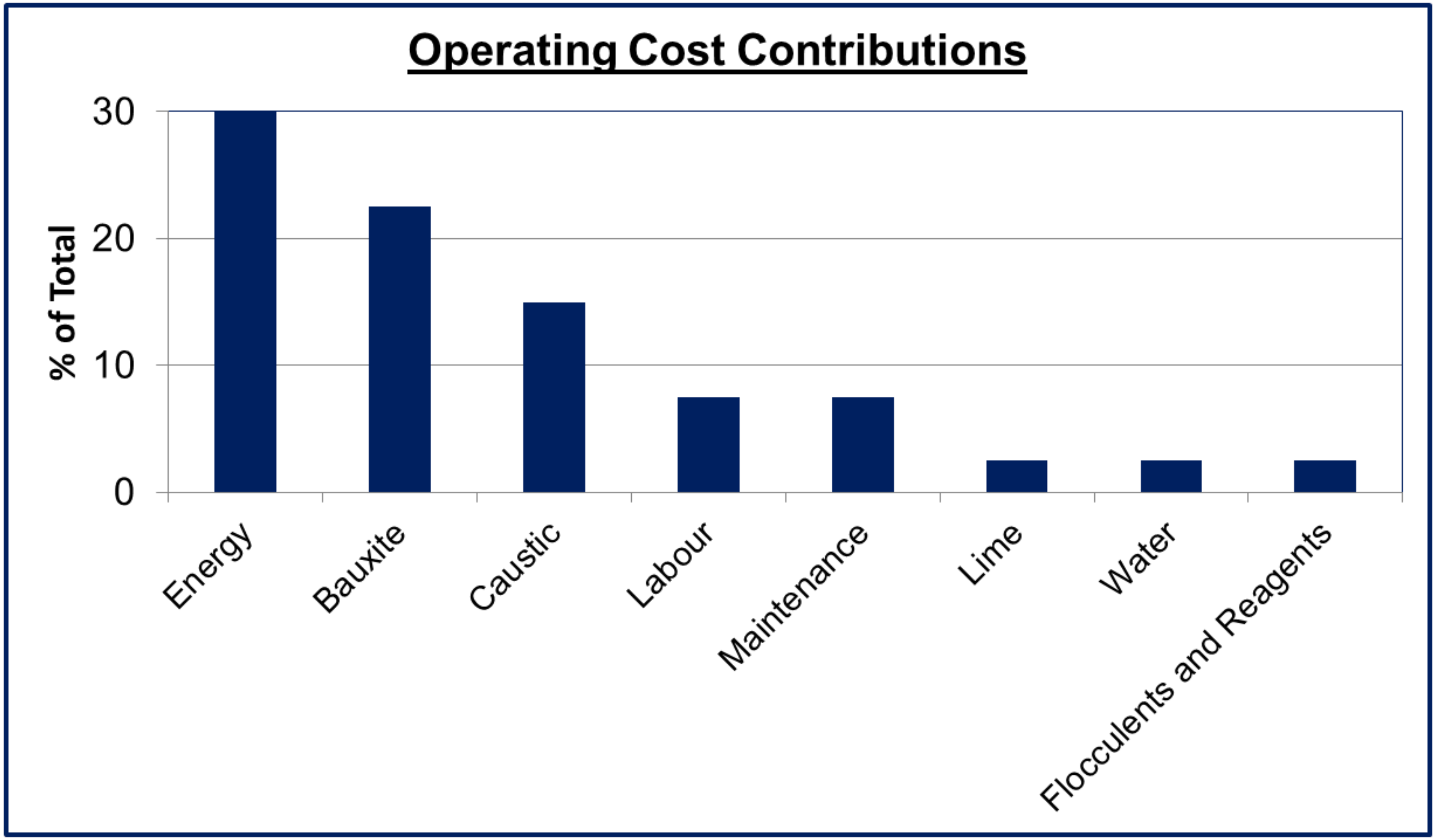
1. Introduction

- Industry is facing almost unprecedented parallel challenges on the supply Vs demand curve, pricing structures and escalating pressures on energy costs.
- Over the last 30 years, many refineries based on the Bayer process have seen some innovation in red mud disposal technologies & organics removal processes but have largely remained stagnant on major process improvements to reduce operating costs.
- Over the last 10 years, we have seen refineries in Jamaica, China, U.S., Italy, Romania and Australia close as a result of unsustainable cost pressures and the use of old technology.
- It is clear that energy costs and innovation will become increasingly key factors in the success of new projects & existing refineries.

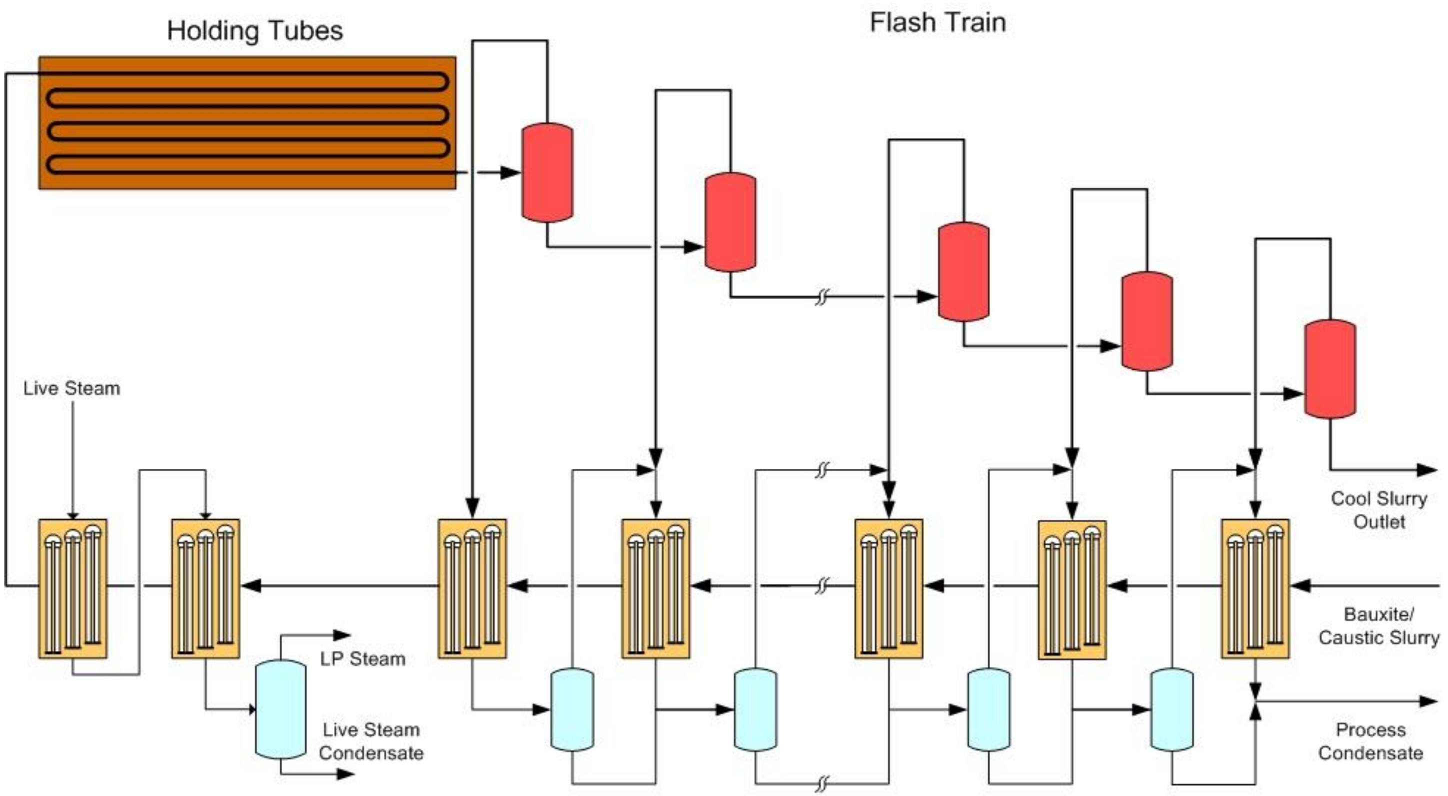
1. Introduction



1. Introduction



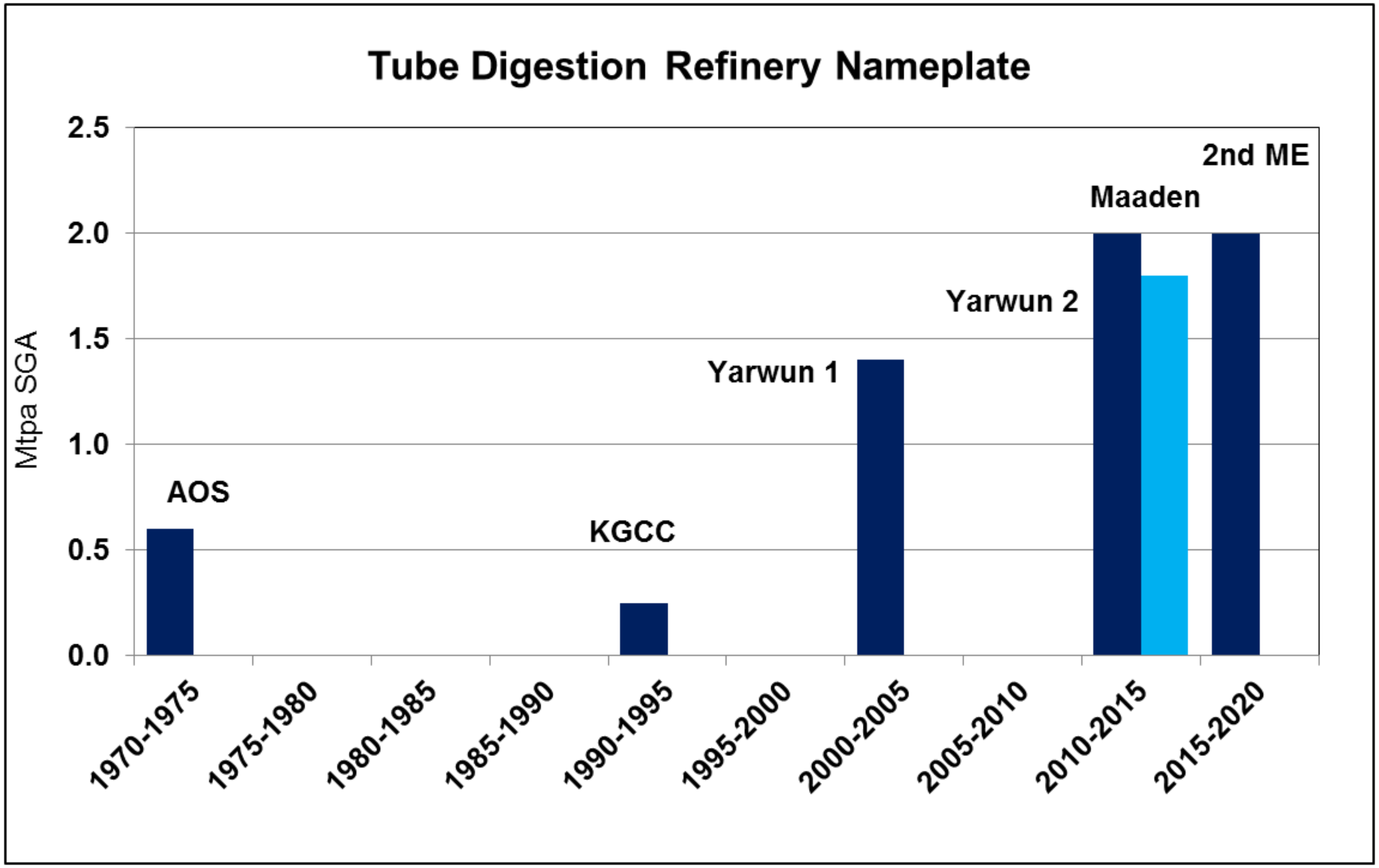
2. Single Stream Tube Digestion – Why?



2. Single Stream Tube Digestion – Why?

- Provides an optimal thermal match between heat sink and heat source minimizing Digestion energy and refinery energy.
- Eliminates the need for steam injection and additional liquor circuit evaporation requirements, installed capital cost and associated LP steam consumption (energy).
- Reduces the size and capital cost of the boiler facilities.
- Maximises liquor productivity ie, alumina production per volume liquor through Digestion thereby reducing equipment & piping sizes.
- Reduces heater cleaning frequencies to 3-9 wks
- Eliminates requirements for exotics in materials (Nickel, alloys, Duplex steels etc) in heater circuit.
- Allows retrofit for Wet oxidation for long chain organics breakdown

3. Tube Digestion Evolution Timeline



3. Tube Digestion Evolution Timeline

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- AOS (Aluminium Oxide Stade) 1973.

- Initial nameplate 0.6 Mtpa SGA with expansion to 0.925 Mtpa as at 2006.
- Multiple (4 off) single train units.
- Optimal thermal energy
- Less prone to tube blockages
- Elimination of heater tube erosion
- Wet Oxidation used to reduce organics buildup and restore precipitation yield, liquor productivity, reduced liquor dead volume and stabilised alumina particle size.

3. Tube Digestion Evolution Timeline

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- Korean General Chemical Corporation 1993.
  - Multi-cell heating technology to produce hydrate for specialty aluminas.
  - Capacity 0.22 Mtpa hydrate.
  - Digestion temperature 260degC
  - Pre-cursor to KLV Joint Venture (Kaiser Engineers, Lurgi & VAW) for Comalco Alumina Refinery (now Yarwun) which commenced study phase in 1995
  - Successful operation provided launch pad for step change in capacity for Tubular Digestion.

3. Tube Digestion Evolution Timeline

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- Yarwun Alumina Refinery; Stage 1 - 2004 & Stage 2 - 2012.

- Nameplate 3.4 Mtpa SGA.
- 0.7 & 1.0 Mtpa units with multiple heater train arrangements.
- Easily integrated with evaporation.
- Jacketed pipe heater chemical cleaning every 3-5 weeks
- Less prone to tube blockages
- Elimination of heater tube erosion
- Reduction in refinery complexity
- Reduction in refinery evaporation & energy

3. Tube Digestion Evolution Timeline

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- Ma'aden Alumina Refinery (Hybrid Tubular Digest) - 2014.

- Single stream to 200degC
- Steam injection into Autoclaves for target 270degC
- Titanate scale avoided

- Nameplate 1.8 Mtpa SGA.
- 0.9 Mtpa units with multiple heater train arrangements.
- Export energy from Digestion integrated with evaporation and Boilerplant.
- Digestion temperature at 270degC
- Jacketed pipe heater chemical cleaning every 9 weeks
- Reduction in refinery complexity

3. Tube Digestion Evolution Timeline

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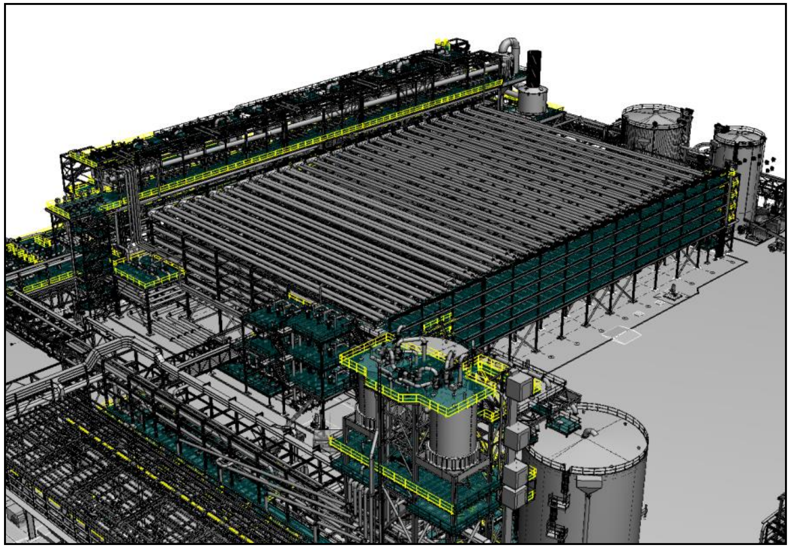
- 2nd Middle East Alumina Refinery – Commissioning 2017/18.



- Increased integrity to avoid CUI
- Additional provisions to enhance operational availability.

- Nameplate 2.0 Mtpa SGA.
- 1.0 Mtpa units with multiple heater train arrangements.
- Jacketed pipe heater chemical cleaning every 3-5 weeks
- Less prone to tube blockages
- Elimination of heater tube erosion
- Minimised Digestion energy
- Thermal oxidiser incorporated for destruction of organics in vent stream

4. Key Metrics

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	Process Parameter	Unit	AOS	Yarwun	Ma'aden	2^{nd} Middle East
1	Refinery Nameplate	Tpa	0.60 now 0.925	Y1-1.4 Y2-2.0	Phase 1- 1.8	Circa - 2.0
2	Digestion Energy	GJ/t	2.7	3.2	6.1[3]	2.8[4]
3	Refinery Energy	GJ/t	7.4[1]	9.2	-	7.4-8.4[1]
4	Liquor Utilisation[2]	-	-	0.81	0.96	0.75
5	Digestion temp	°C	270	270-280	270	270-280

Notes
1 - Excludes electrical energy,
2 - Relative liquor utilization when compared to a typical dual stream flowsheet
3 - Digestion and Evaporation thermal energy after boiler house export
4 - Estimated parameters only

4. Key Metrics

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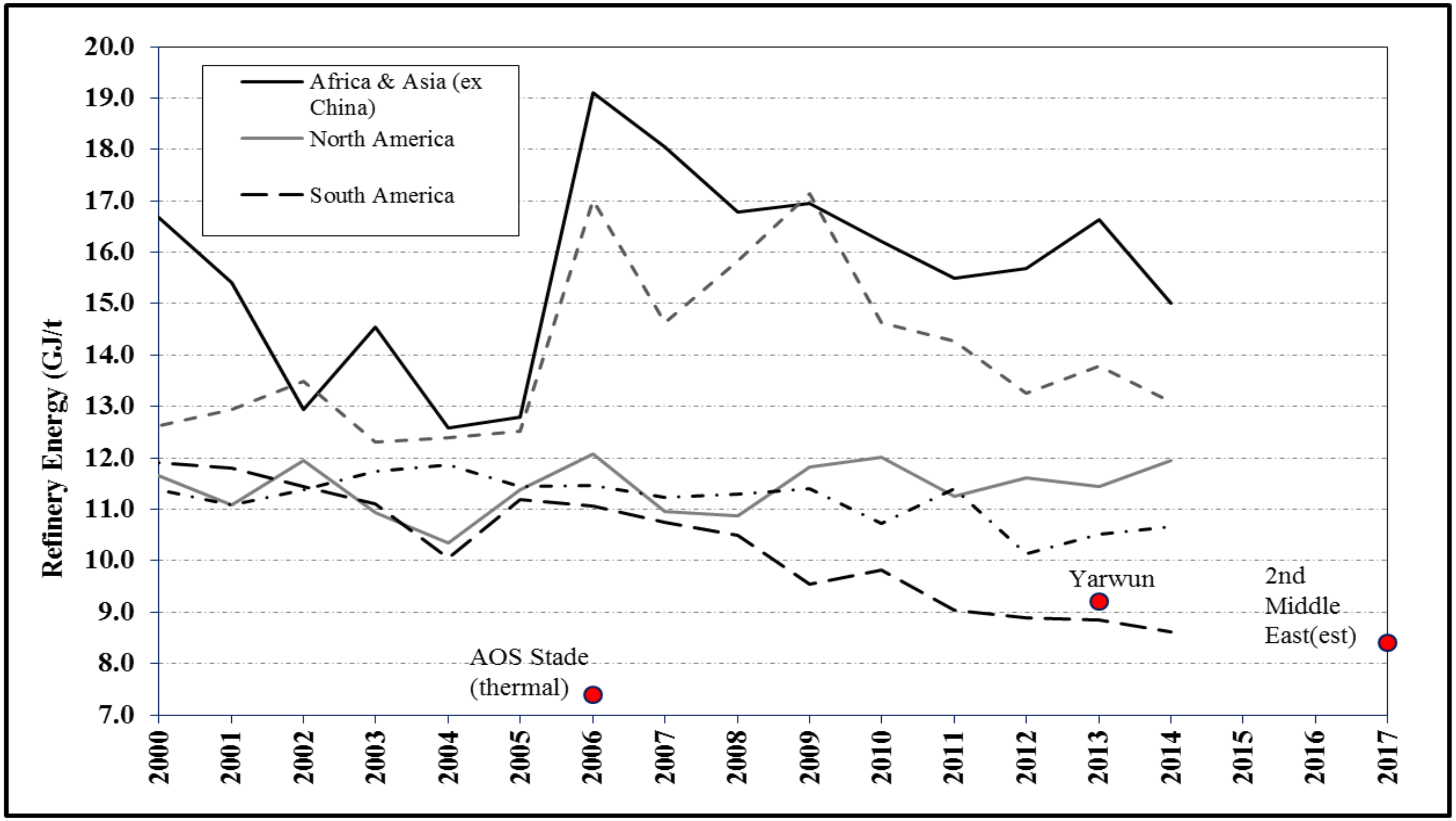
Metallurgical Alumina Refining Energy Intensity



Source IAI – refineries producing 90% or more of total output as metallurgical grade alumina

5. Future Developments

- Has economy of scale reached a practical maximum?
- Incremental energy savings.
- Incorporation of Wet Oxidation
- Application to brownfield or retrofit.
- When compare to the automotive or electronics and IT industries over the same time span (eg smartphones), these advancements still look incremental and painstakingly small.

  What Δ is needed for next evolution??
- And what industry partners will take risk in a climate of capital restriction and contractual models of PG's and warranties??

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Thanks For Your Attention

Questions/Comments welcome.