Rio Tinto Alcan

Current increase, power efficiency improvement and PFC reduction at RTA Bell Bay Smelter

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Presented on behalf of Bell Bay Potrooms

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Topics

- Introduction to the Bell Bay smelter.
- Production increase through significant current creep and process optimisation (1988-2008).
- Perfluorocarbon emission reductions by targeting zero anode effects.

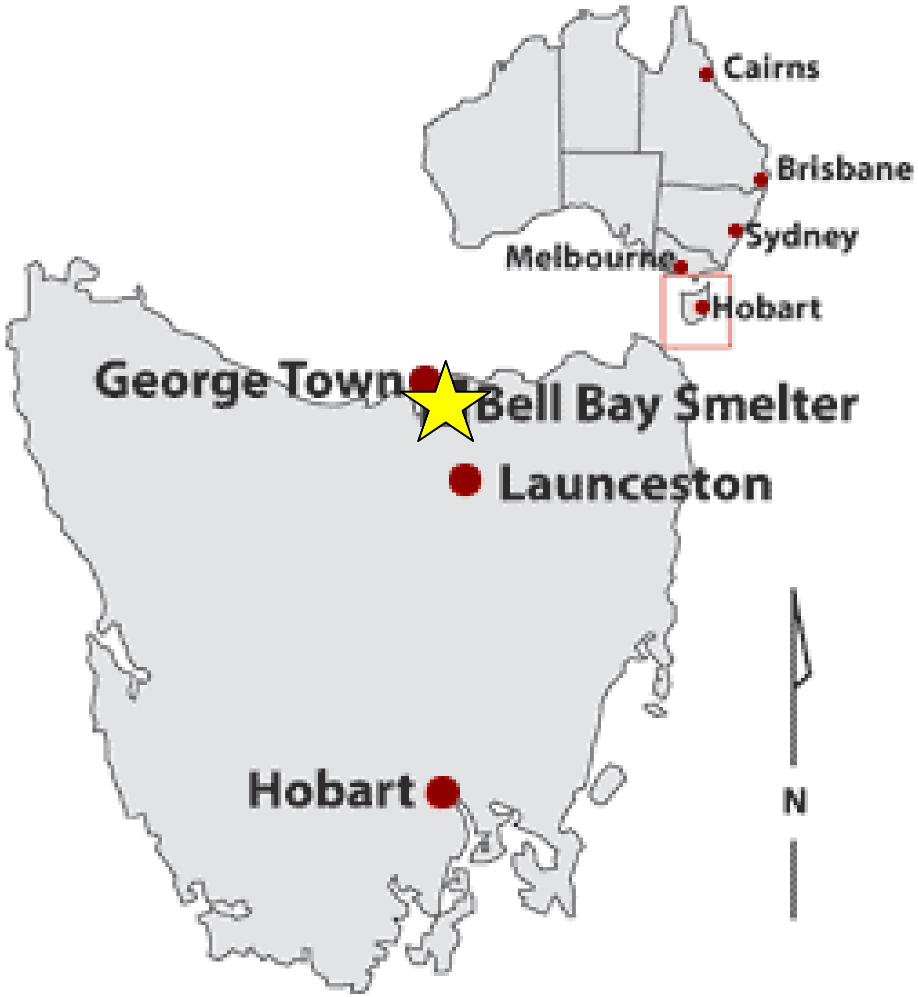
I'd like to take this opportunity to describe two significant improvement initiatives undertaken at the Bell Bay Smelter.

The first initiative is the result of the plant's unrelenting drive to improve production and productivity, while reducing costs, by creeping current to levels that were not considered possible twenty years ago.

The second initiative is the potroom's concerted effort to reduce anode effects (both in frequency and duration) to a level where their environmental impact is minimised.

But firstly I would like to introduce you to the aluminium smelter.

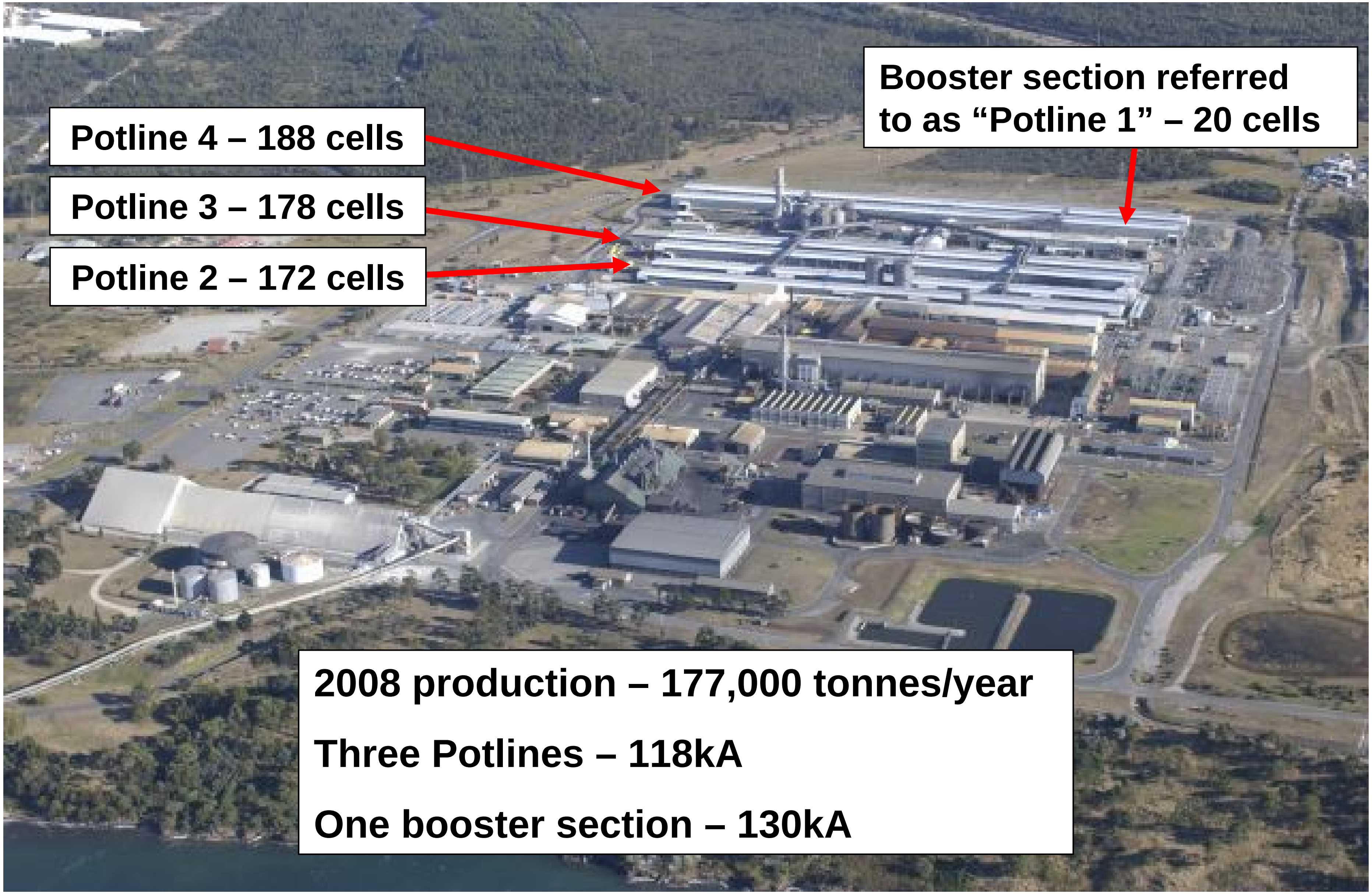
Bell Bay Aluminium Smelter

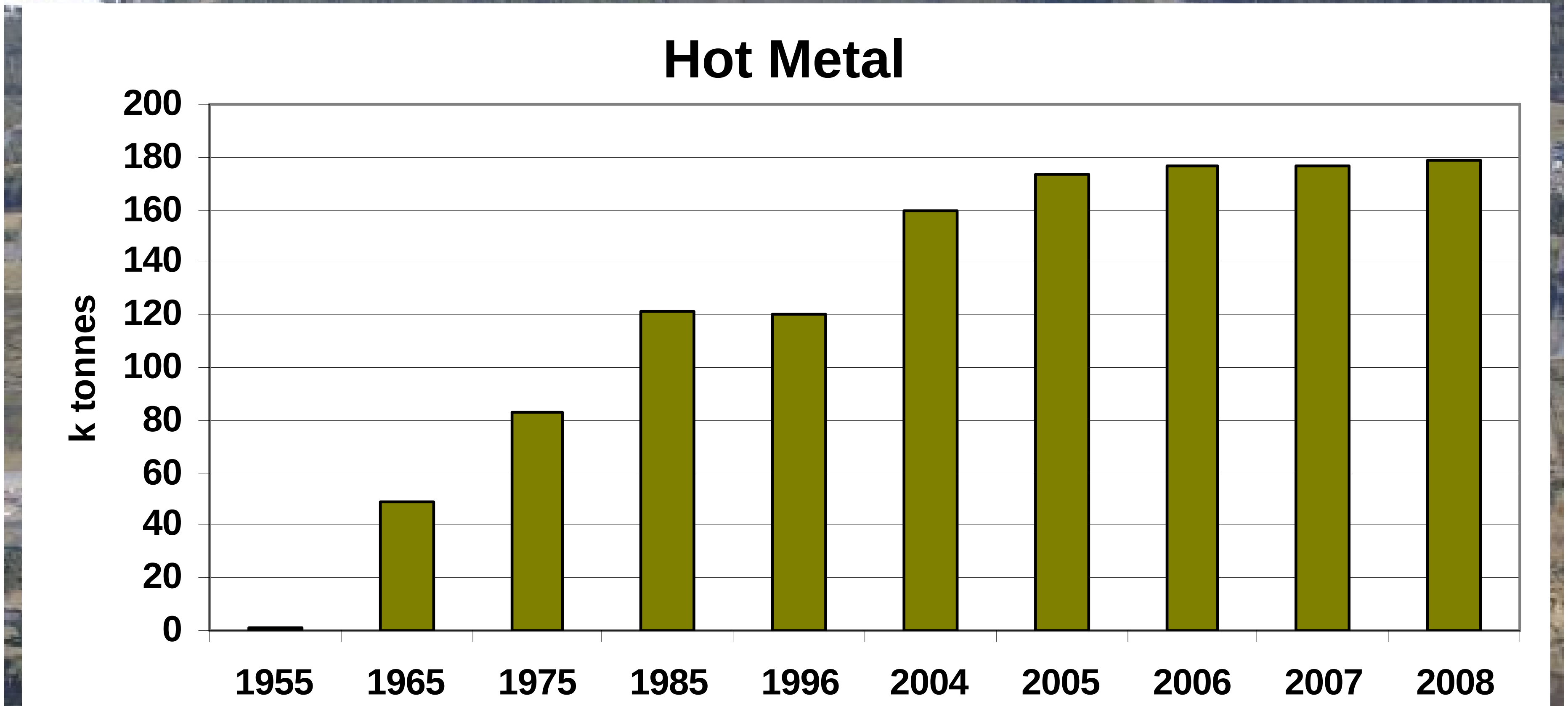


- First aluminium smelter in the Southern Hemisphere.
- Began production in 1955 as Government owned facility.
- First potline VS Søderberg.
- Acquired by Comalco in 1960 heralding start of Australia's integrated aluminium industry.
- Bell Bay is now one of three Rio Tinto Alcan smelters in Australia, but the only one wholly-owned.

As shown on the map, the Bell Bay smelter is located in Northern Tasmania, close to George Town, a town with a population of around 7,000 situated close to the mouth of the Tamar River.

The Søderberg potline (Line 1) was shut down in 1981.


Potline 4 – 188 cells
Potline 3 – 178 cells
Potline 2 – 172 cells
Booster section referred to as "Potline 1" – 20 cells
2008 production – 177,000 tonnes/year
Three Potlines – 118kA
One booster section – 130kA



Capacity has grown over the years, initially through potline expansions, but more recently through amperage increase and efficiency improvements. This has put significant pressure on improving work practices and process control to maintain cell performance and minimise environmental impacts, particularly from anode effects.

The cells are Kaiser P57 side-by-side end riser technology, developed in the 1950's. They were originally equipped with centre bar breakers but were later converted to point feed (more on this later).

The cell hoppers are filled with reacted alumina, from the scrubbing system, by overhead crane. The dry scrubbing system is Comalco developed Torbed technology. Alumina is sourced from either QAL or Rio Tinto's new Yarwun refinery in Queensland. Both source bauxite from Weipa. Alumina is delivered to an "A" frame storage shed on site.

The cell control system was developed in-house and includes a computer per cell, linked to middle level supervisory computer per 16 cells. The user interface is via a top level computer system that includes an extensive data base.

Each Potroom is serviced by one general purpose crane and one anode changing crane (CTM)


Anode
setting


DEMAG
Filling alumina
hoppers

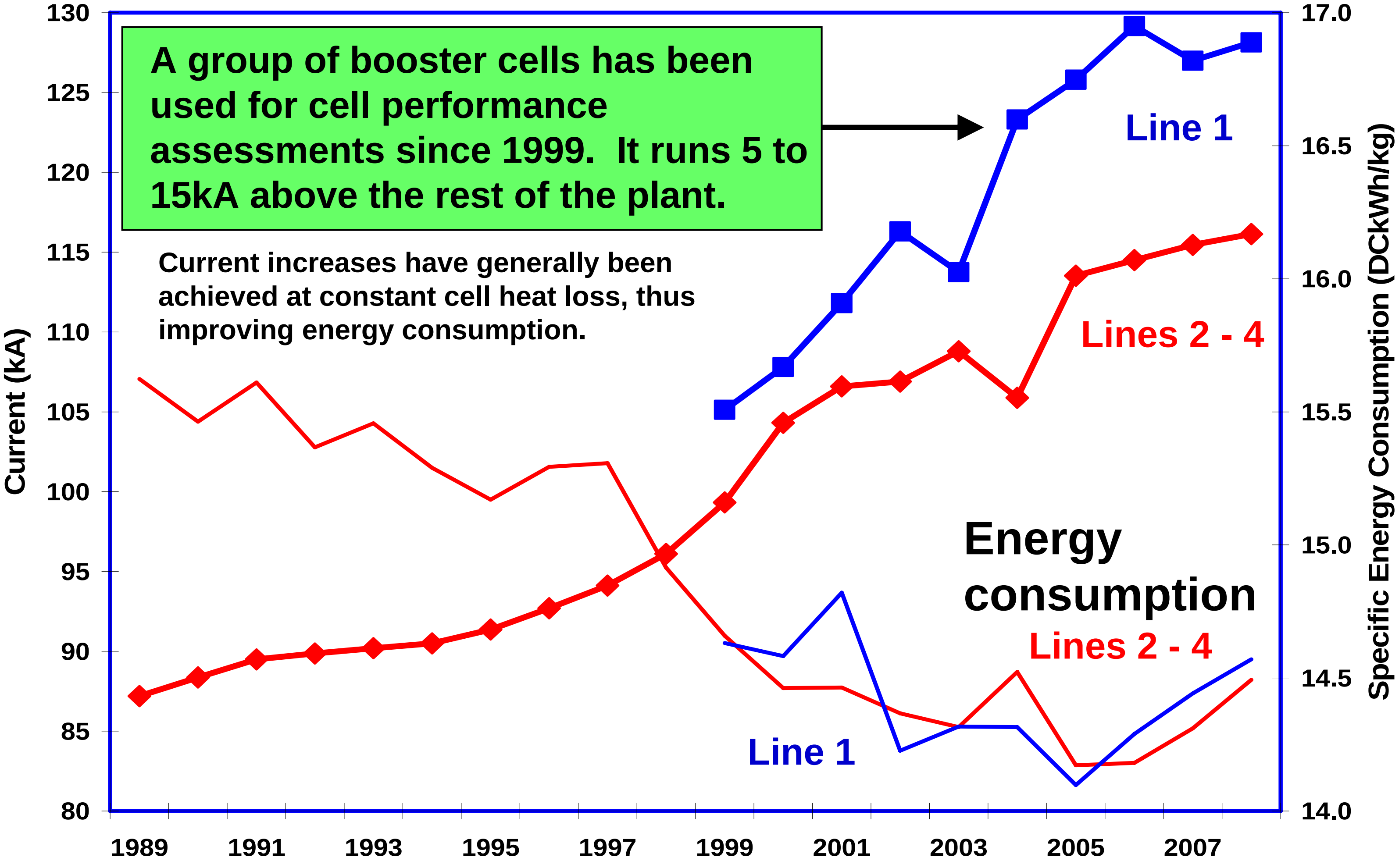

Cell
Dressing


Metal
tapping

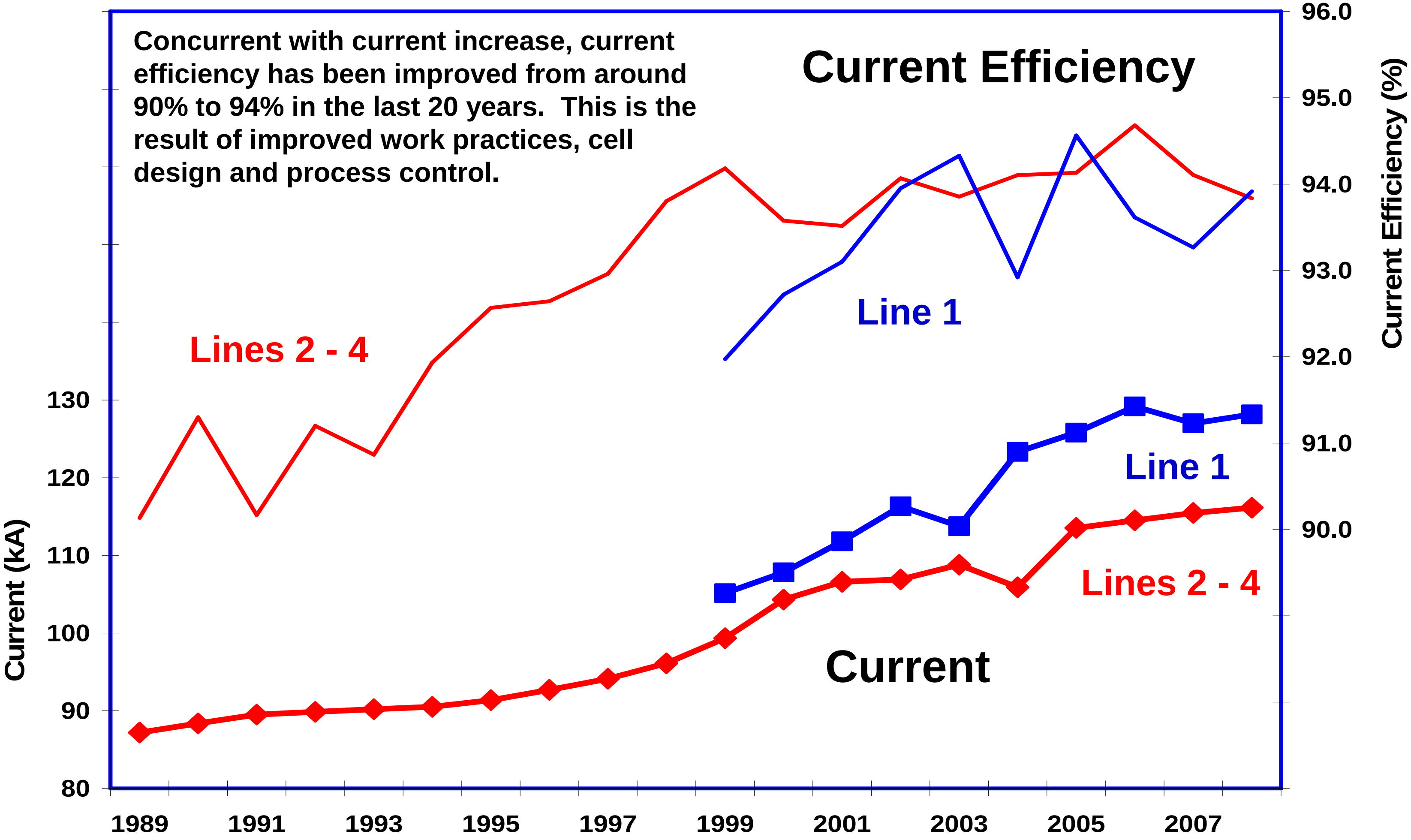
Challenges

- Bell Bay is a relatively small output smelter operating an older technology.
- To remain competitive requires continual improvement in efficiency, cost and productivity.
- 2008 targets included:
  - 2% year on year production increase.
  - 2% year on year controllable cost reduction.
  - Reduced site GHG emissions (1.75 tCO_2e/t Al)
- 2009 aim is primarily survival:
  - Minimum CAPEX and OPEX
  - Maximum efficiency and minimum waste

Continuous story of current creep



PE improvements have resulted from increasing CE and cell squeezing strategy



Current increase capability enablers

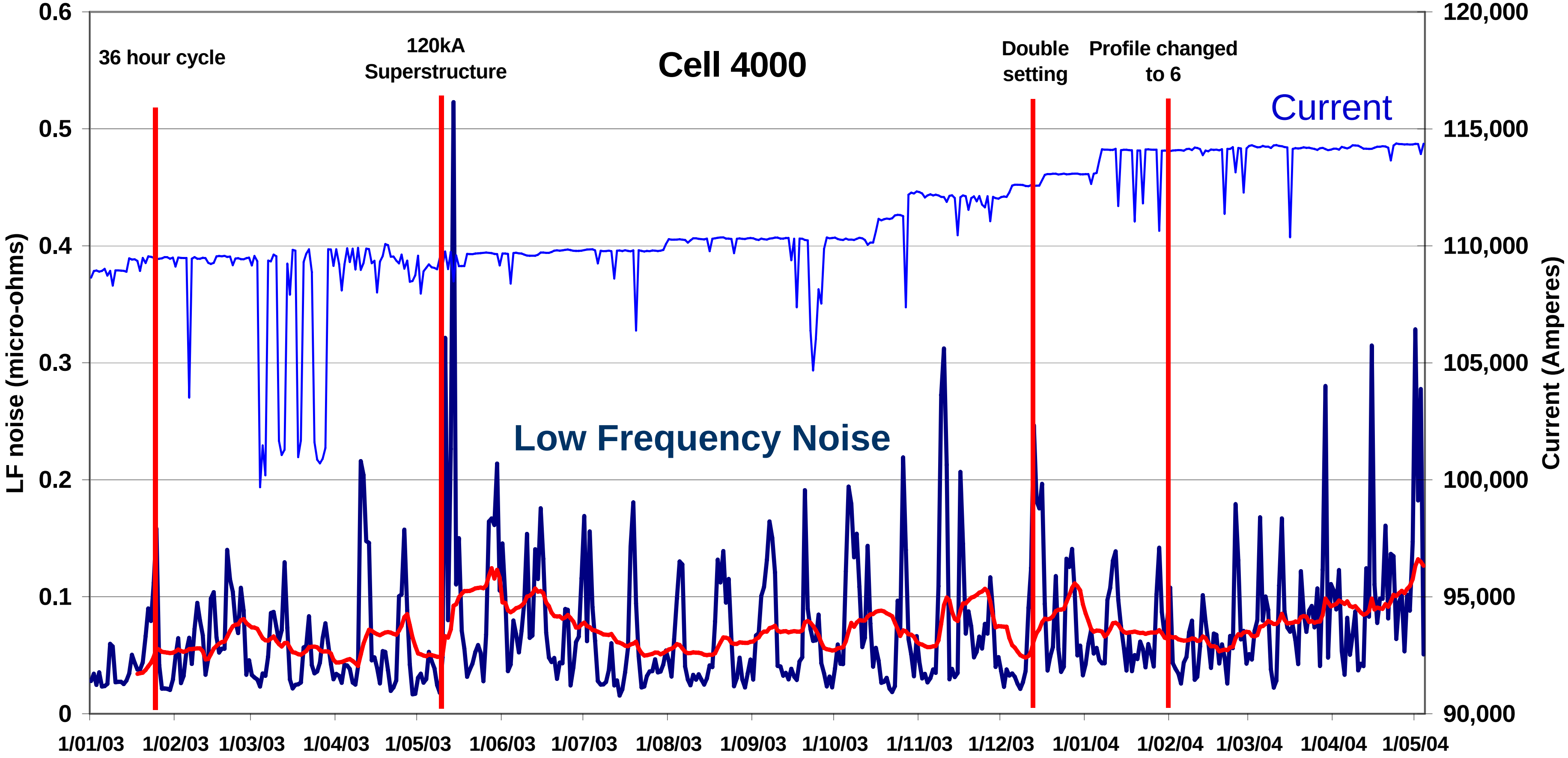
1980 - 85	814 x 525mm anode,100mm diameter stub
1989	860mm asymmetric anode
1996	130 mm dia. stub, symmetric hanger, cut fume skirts, chamfered anode back
1997	Torbed dry scrubber fume treatment plant installed
1998	925mm asymmetric anode, point feed on-line conversion
1999	Increased downstream cathode busbar cross sectional area
2000	945mm asymmetric anodes, CTM anode setting, lower anode cover
2002	165mm tall anode slot, deck plate cutting
2003	120 kA superstructure on line conversion with wider anode spacing and extra anode bus. 945 symmetrical anodes. Change from 48 hour to 36 hour tap.
2004	Side chamfered anodes
2006	560mm wide Anode (Carbon Baking Furnace packing layers reduced)
2007	200mm tall anode slot

Cells were heat balance constrained

- Cathode heat balance improved at higher current, resulting in a lower cathode electrical resistance. Prior to this point cells were probably limited by heat balance (too cold).
- Gains from 1996 onwards were largely from heat balance improvement with increasing current.
- Removing cover from hangers in 2001 allowed higher current density (scaling of the steel hanger was an issue)

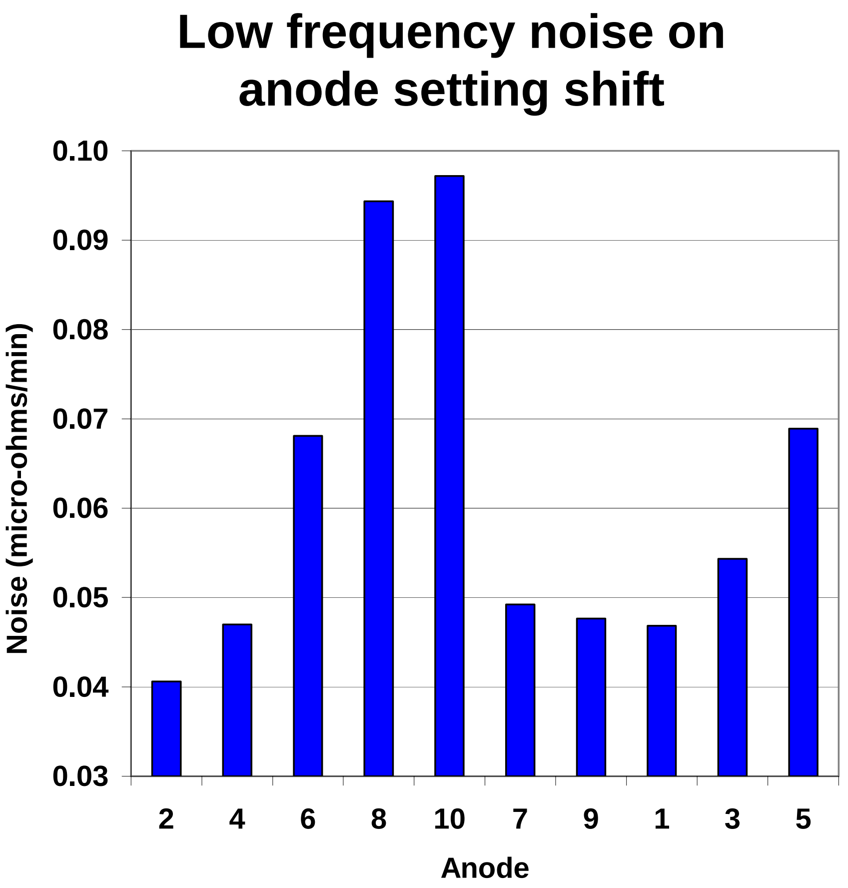
Year	1985	1990	1991	1996	1999	2001
stub dia mm	100	100	100	130	130	130
amperage kA	86	88	92	94	100.5	107
anode length mm	814	860	900	900	925	945
anode width mm	525	525	525	525	525	525
anode cd amps/mm sqrd	0.0101	0.0097	0.0097	0.0099	0.0103	0.0108
Cathode Resistance typ micro Ohms				4.8	4.2	4.1

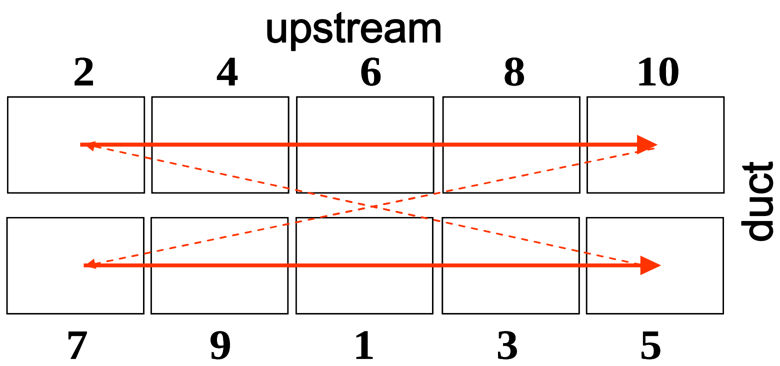
Impact of anode setting sequence

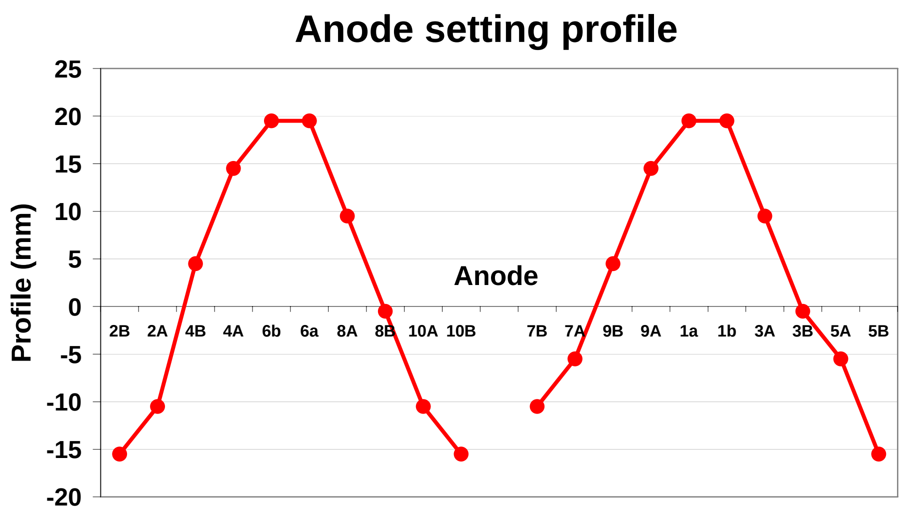


Instability associated with setting upstream duct end anodes was evident before superstructure changes and current increase (as evidenced by the cyclical increases in low frequency noise before June 2003), however it deteriorated after these changes.

Impact of anode setting sequence

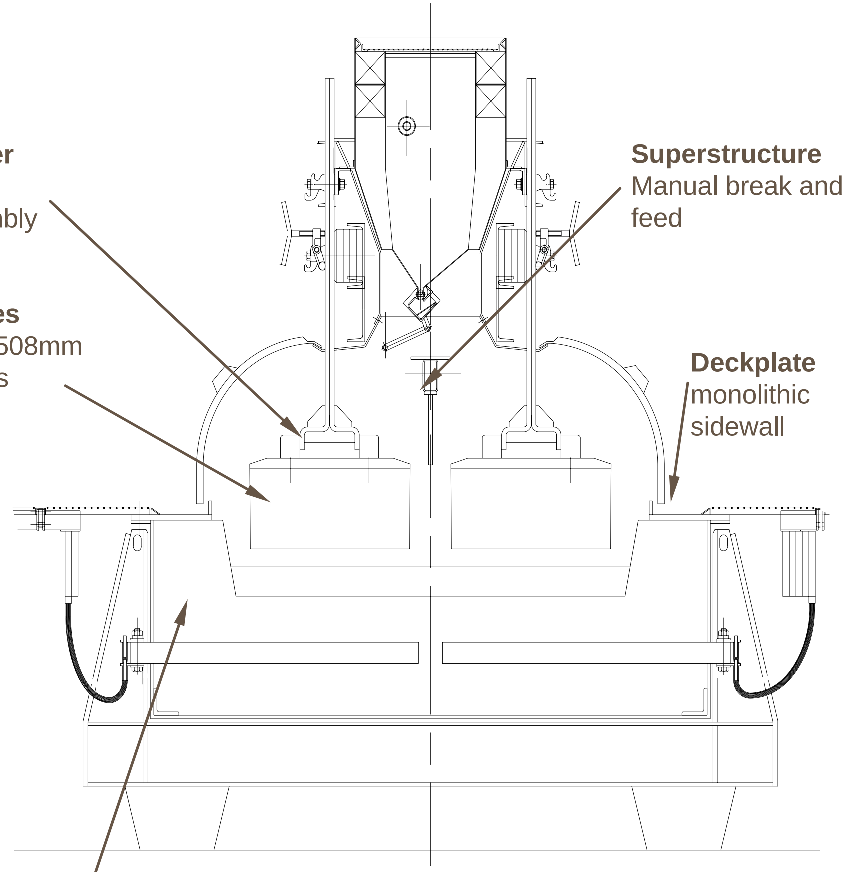




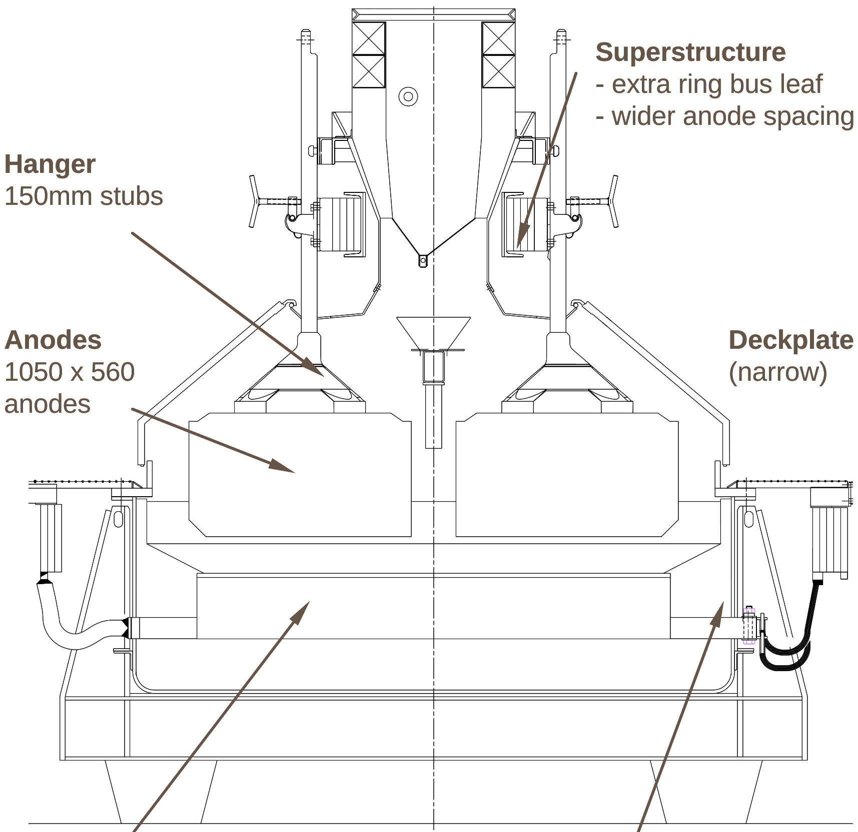


Stability issues were resolved by reversing the anode setting sequence, modifying the anode setting profile and parameters

Continuous hardware improvement

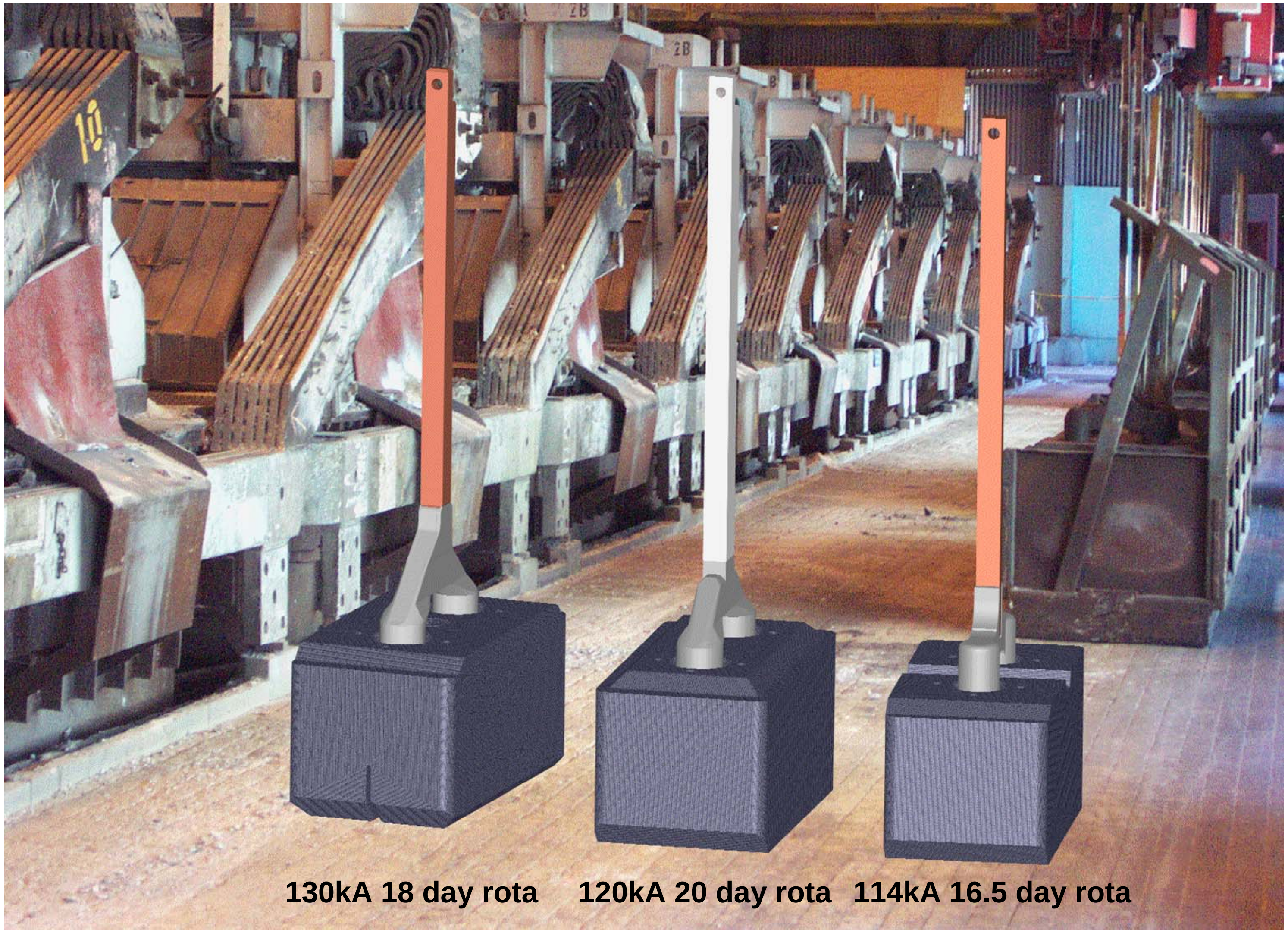


Original 1961 Design



130kA (2006)

Anode assembly development



Typical cell performance (12 month averages)

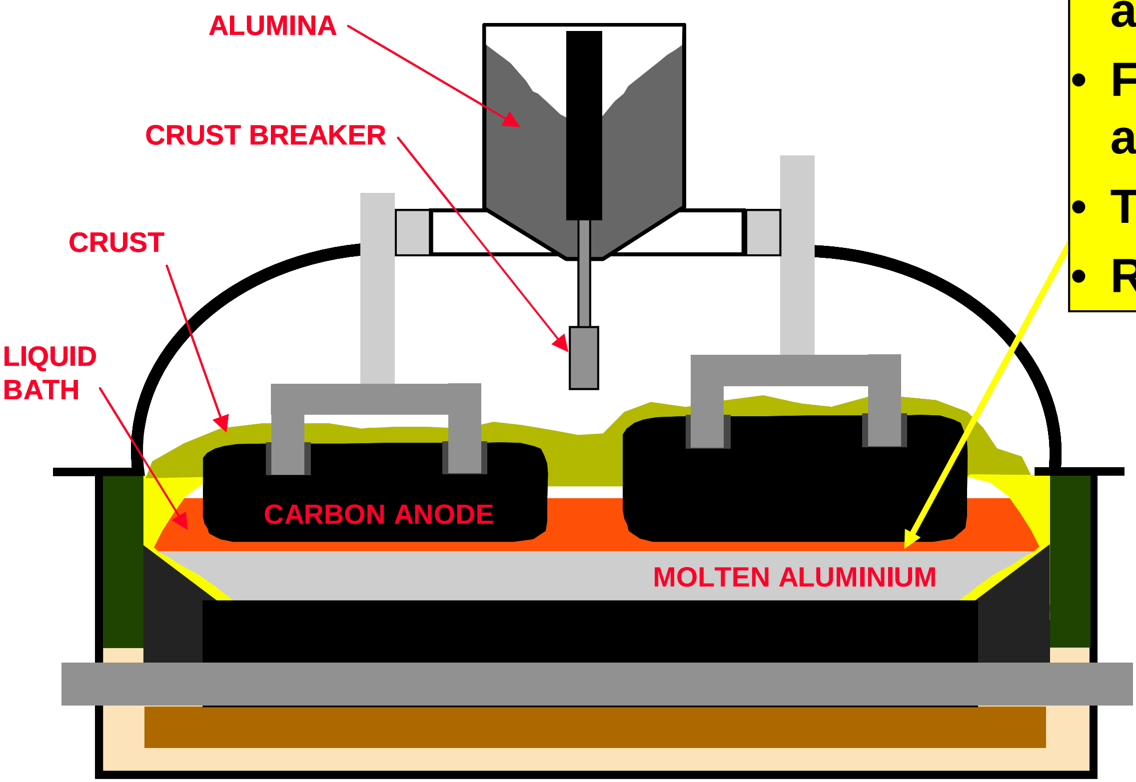
Critical Process Variable/End-Of-Line	Line 4 2008	Line 1 2008
Current (kA)	116.0	128.1
Volts/cell (V)	4.56	4.59
Anode length (mm)	945	1050
Anode current density (A/cm^2)	1.10	1.09
Bath temperature (degrees C)	959	966
Excess aluminium fluoride (%)	12.3	12.2
Current efficiency (%)	93.9	93.9
Spec. Energy Consumption (DC kWh/kg)	14.5	14.6
Power actual (kW)	516	539
Net carbon (kg/kg Al)	0.436	0.395
Anode effect frequency (AE/cell day)	0.063	0.10
Average iron concentration (%)	0.087	0.071

130kA Project

- Ramping to 130kA will increase metal production by 23kt (13%).
- Large productivity gains planned through amperage creep, automation and workflow optimisation.
- Enablers are larger anode, new anode hanger and cell designs and power supply upgrades.
- Estimated CAPEX of US$35.

As a result of the global financial situation, resulting in a collapse in aluminium price to around US$1,350/tonne, the 130kA project is presently under review.

Perfluorocarbon (PFC) emissions



Cross section of a reduction cell

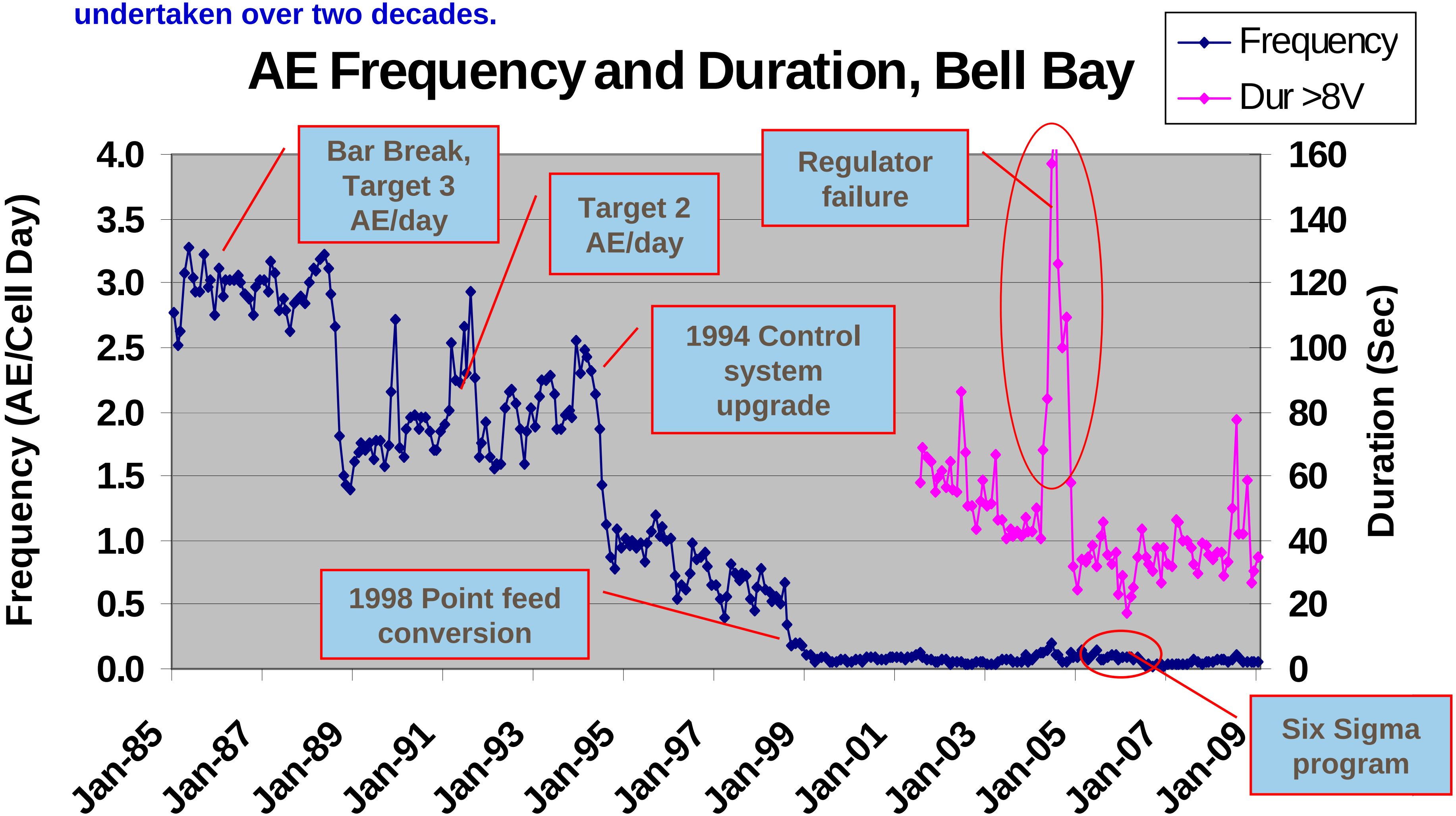
- **At low alumina conc. (~1.5%) anode polarisation increases.**
- **Fluorine ions of the liquid bath are discharged.**
- **These react to form PFC gasses.**
- **Result in an "anode effect"**

Compound	Global Warming Potential (100-year horizon)
CO_2	**1**
CH_4	21
HFC-134a	1,300
CF_4	**5,700**
C_2F_6	**11,900**
SF_6	23,900

The generation of PFC emissions during anode effects, with their very high green house gas contribution, is well established.

Anode effect (AE) Performance over time

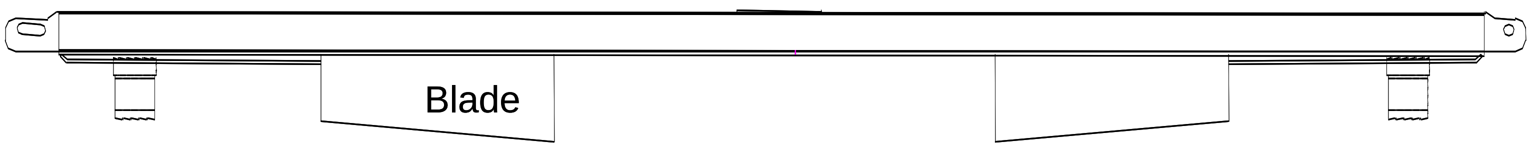
Campaigns to reduce anode effect frequency, and later anode effect duration, have been undertaken over two decades.



Historical anode effect performance

1985 -1994

- 3 anode effects per day
- Centre feed, bar break operation



- 1 break, 3 dump feed strategy (~7kg dump weight)
- No resistance tracking
- Anode effects scheduled
- Considered necessary for sludge control
- Attempt to reduce frequency from 3/day to 2 in 1989
- Two tier Siemens R30 Mini computer/ Siemens MC210 microcomputer

Historical anode effect performance

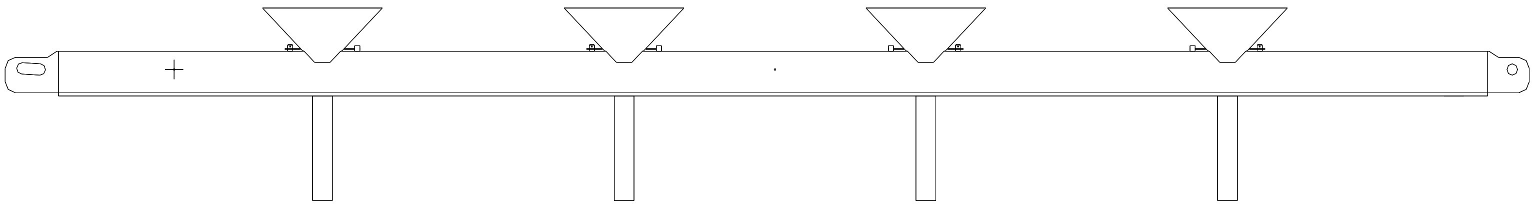
1994 - 1998

- **Major control system upgrade, Comalco-developed cell control strategy**
- **New three tier VAX, IVAX, Analogic computer system**
- **Resistance tracking introduced**
- **No scheduled anode effects**
- **AE frequency reduced to 0.5 ~ 1.0 AE/day (enabled by control strategy improvements)**
- **Still issues with alumina dissolution (back feeding) as a result of alumina sinking into the metal pad from the relative large dump mass during feeding.**

Conversion to point feed

1998

– **Bar breakers converted to point feed, adapted from original bar break beam**



– **4 picks with chutes to direct alumina into feed hole**

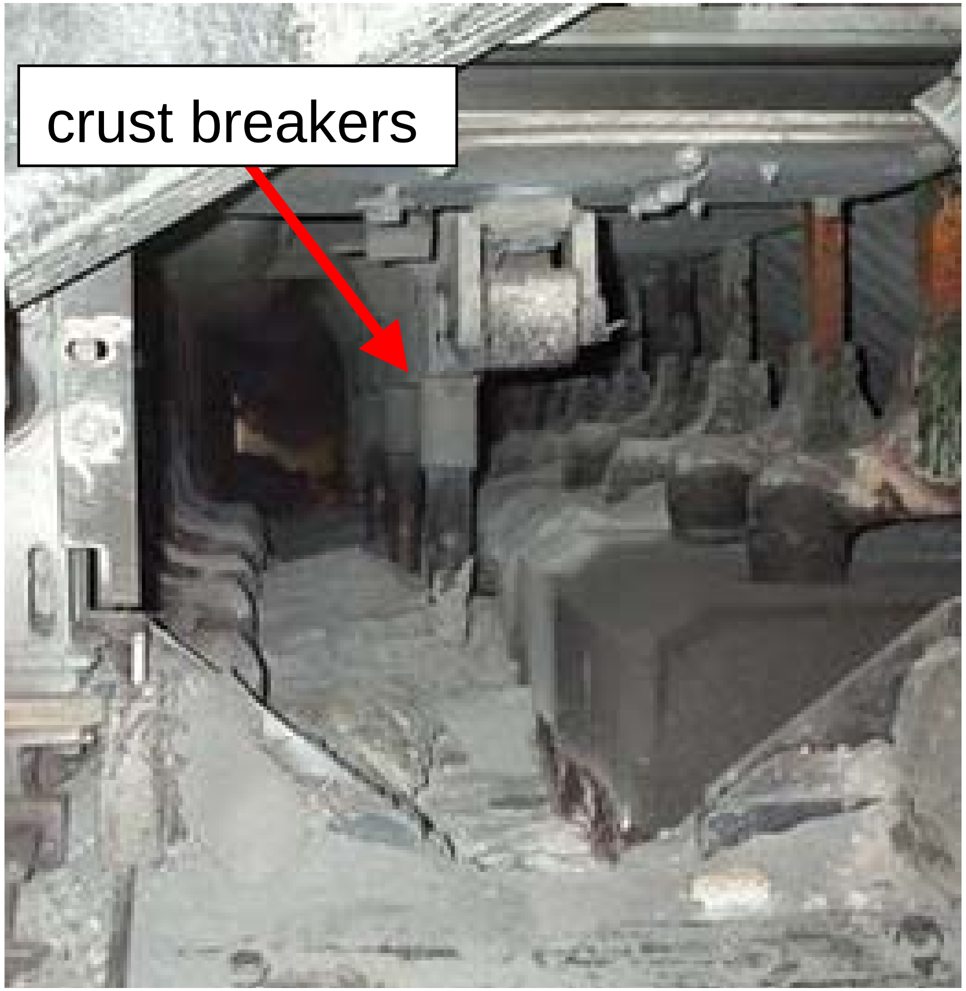
– **Hopper outlets blanked off**

– **Dump gate dams fitted**

– **Pick length and breaker beam stroke optimised**

Point feed conversion considerations

- **On-line beam change out procedure, to avoid safety issues.**
- **Hopper utilisation/ dead capacity.**
- **Pick material selection (304 or 304L austenitic stainless).**
- **Breaker stroke length, pick length and immersion.**
- **Pick location relative to anode position.**



A number of issues needed addressing during the point feed conversion, including:

- **Procedure to allow safe access into cell hoppers using a mobile cooling system.**
- **Pick material selection – early choices saw significant erosion of tip.**
- **Crust breaker pick length and beam stroke – needed to avoid too much submersion in bath to prevent overheating and bath build up.**
- **Ore gates were blanked off to reduce variation in dump weight.**
- **Pick location – early choice resulted in air burn adjacent to anode stubs. Picks were relocated to anode corners.**

Upping the ante on anode effects

2001

- Commenced measuring AE duration (defined as time above 8 volts)

2006

- Greenhouse gas targets established for AE contribution.
- Site Target < 0.07 AE/cell day, 30 seconds duration.
- Expectations set:
  - Goal of zero anode effects
  - Every AE treated as an "exception"
- Six Sigma program commenced:
  - Initially addressing AEs in new cells
  - Expanded to include all cells.

AE reduction focus areas

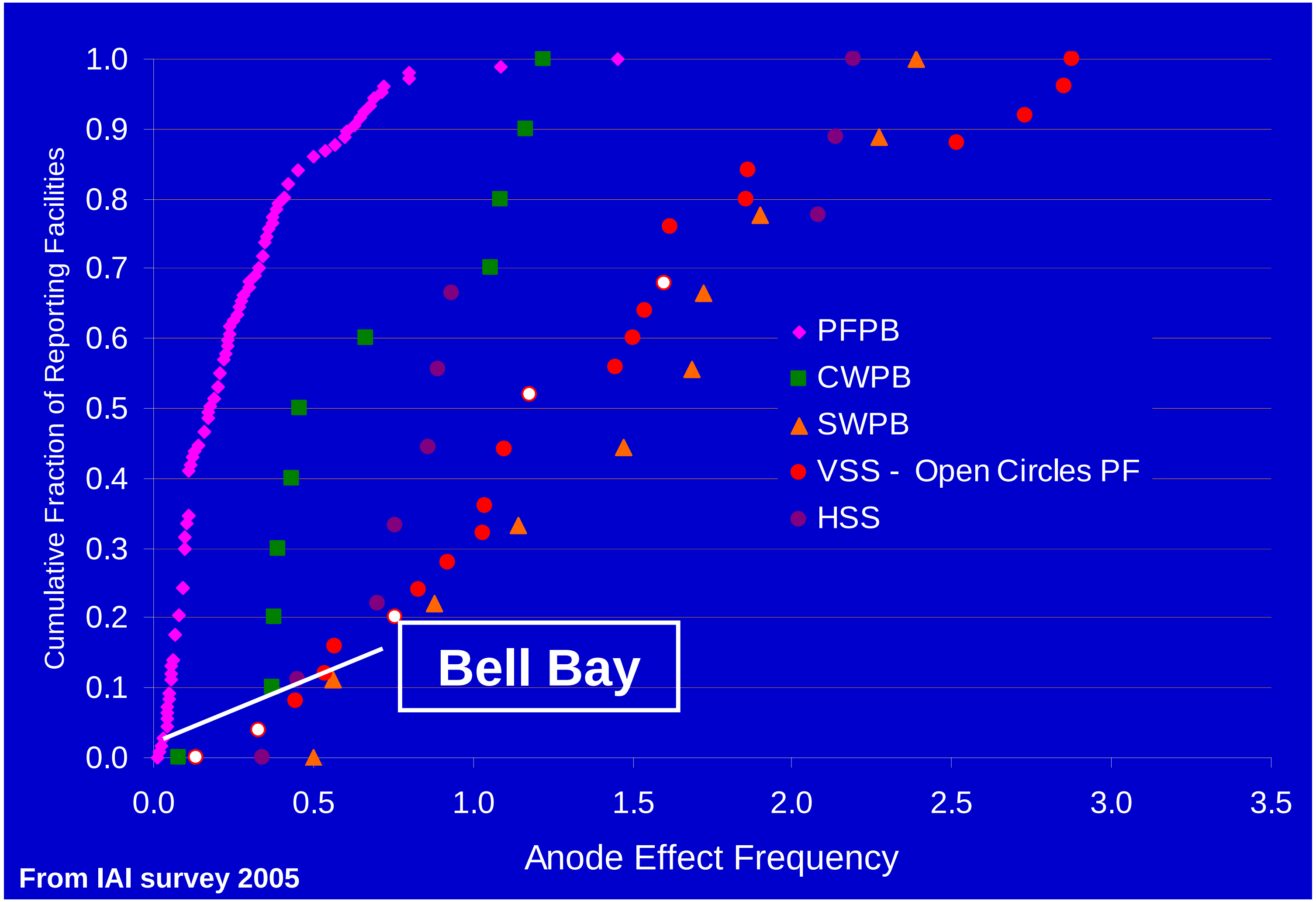
Target areas:

- **New cell start-up control**
- **Alumina feed equipment reliability**
- **Recovery from no load and reduced load**
- **Post anode setting control of ACD**
- **Automatic anode effect termination effectiveness**
- **Resistance tracking parameters (tuning to mitigate the impact of current increase)**
- **Individual cell parameter tuning for alumina dump weight**
- **Individual cell power settings (heat balance control)**
- **Individual exception cell follow up**
- **Adaptive feed**

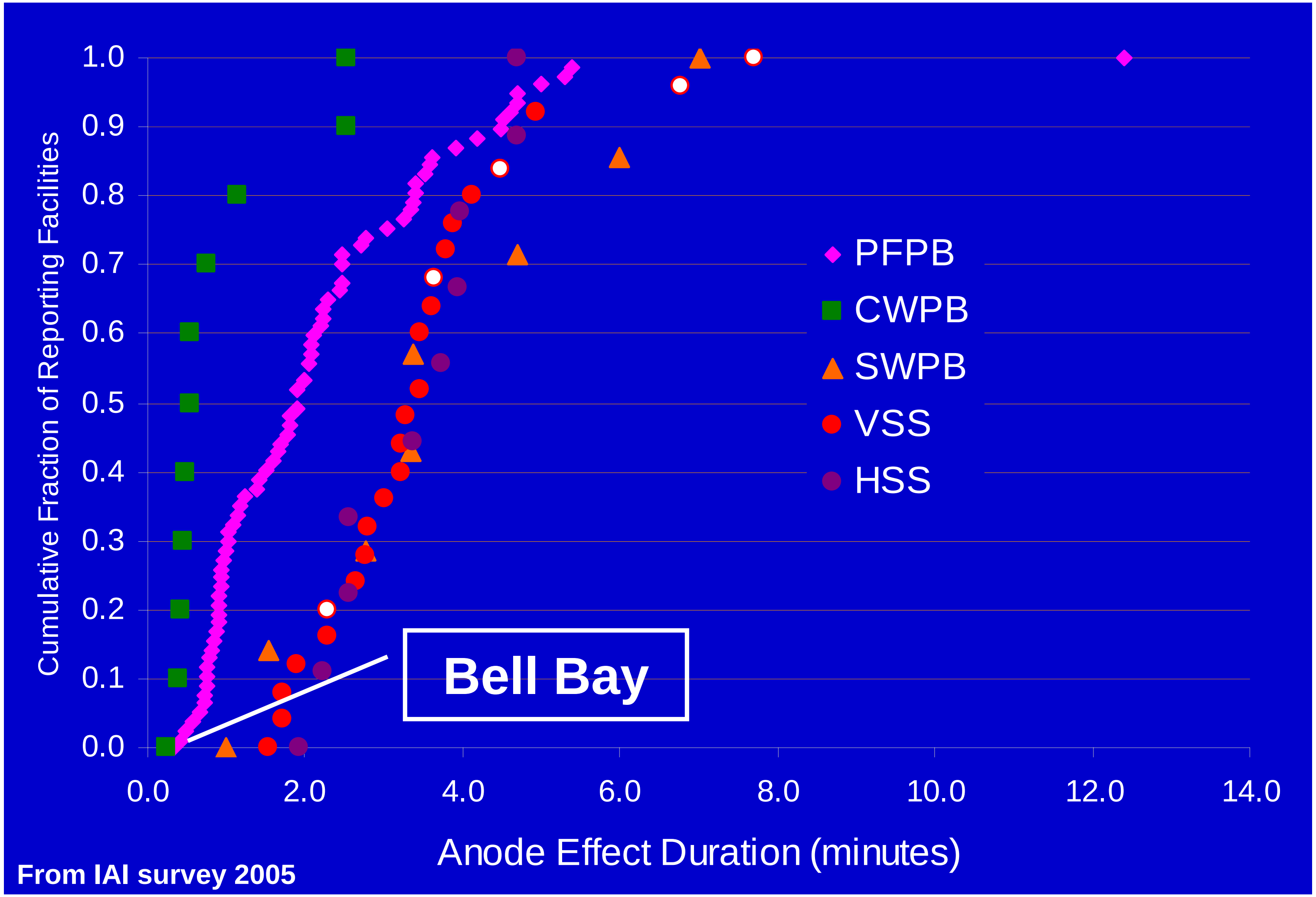
Challenging anode effect myths (that we used to believe!)

- **Anode effects are necessary.**
- **AEs are required for new cells.**
- **AEs are unavoidable after reduced load/no load.**
- **Increasing line current always increases AE frequency.**
- **Larger anode area/decreased bath volume must increase AE frequency.**
- **Alumina source change always causes AEs.**
- **It is too hard to improve from where we are now.**

AE frequency benchmarking



AE duration benchmarking



Benefits of low AE frequency & duration

- Reduced greenhouse gas emissions
- Reduced energy consumption and improved CE
- Reduced crust disruption from AE termination:
  - helps reduce anode airburn
  - helps reduce fugitive fluoride emissions
- Reduced manual intervention to "pole" out failed AEs after failed automatic termination
- Reduced risk of cell failure due to overheating
- Improved amperage stability, hence "gentler" on power supply equipment

Reducing and eliminating anode effects has many other benefits as well as reducing GHG emissions. These include reduced costs, increased safety and reduced process variation.

Summary: Key factors in eliminating anode effects

- Motivation (leadership)
- Improved work practices:
  - Quality of routine work (including maintenance)
  - Diagnosis and prompt correction of problems
  - Tuning of cell control parameters (feed and heat balance)
- Improved alumina feeding equipment design and reliability
- Enhanced automated process control strategy:
  - Eliminating “scheduled” anode effects
  - Tighter control of alumina concentration
  - Improved anode effect termination
  - Better cell management around periods of reduced power
- Process Stability

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Acknowledgements

Bell Bay performance achievements are a testament to the Operations and R&D staff who have continually challenged the limits and extend them. Thanks to John Lemberg, Mark Fyfe, Robbie Matthews, Greg Picot, Greg Hardie, Allan Graham and many others.