



Direct Smelting Technology

## Alternative Process for Ironmaking without Coke – The Hismelt® Process & its relevance to India

28<sup>th</sup> February 2008



# Agenda

- **Introduction to Rio Tinto**
- **Hismelt Technology Overview**
- **Kwinana Hismelt Plant Update**
- **Future Technology Developments**
  - CO<sub>2</sub> Reduction Options



# Hismelt's fit with Rio Tinto

**Rio Tinto**

- Aluminium (RT Alcan)
- Copper
- Diamonds & Gold
- Iron Ore**
- Industrial Mineral
- Energy
- Exploration
- Technology & Innovation



- Rio Tinto is a world leader in finding, mining and processing the earth's mineral resources
- The Group's activities span the world...

# Rio Tinto Group's Operations

– Rio Tinto Iron Ore (RTIO) has a global presence



# Hismelt Technology Overview



# The Kwinana Hismelt Plant: 0.8Mtpa Capacity

– A small footprint



# Strong international interest in Hismelt

- **China's top three politicians have visited the Kwinana plant**
  - **Hu Jintao**, President of the PRC (Sept-07)
  - **Wen Jiabao**, Premier of the PRC (April-06)
  - **Wu Bang Guo**, Chairman of China's NPC\* (May-05)
- **~35 site visits by major Chinese steelmakers**
  - Two licences signed with Laiwu Steel and Huaigang
- **Site visits from major steelmakers including Indian, European, Japanese, Korean, North-American, ROW**



## Rio Tinto's revolutionary steelmaking technology attractive to Chinese steel mills, worrying coking plants

# 力拓颠覆百年炼铁术 中国钢厂青睐焦炭厂胆寒

本报记者 勾新雨 佩斯、墨尔本报道

在西澳大利亚人烟稀少的小城佩斯,年轻的迈克尔·巴克利礼貌地向本报记者递上了一张中文名片。接待络绎不绝的中国客人,几乎是他最近两年最重要的工作之一,这些客人中除了中国各大钢铁企业的代表以外,甚至包括中国总理温家宝和中国人大委员长吴邦国。

迈克尔·巴克利是力拓集团旗下属的Hismelt奎那那工厂的市场经理,几乎所有的中国客人都对他所介绍的Hismelt直接熔融还原炼铁技术感兴趣,这项技术不但颠覆了一百年的高炉炼铁技术,更重要的是能够大幅度促进钢铁业的节能减排。

现在力拓公司不仅准备用此项技术来解决它在中国铁矿石市场的后顾之忧,还打算借此和中国首钢一起来谋划更遥远的未来。

### 醉翁之意

6月5日,中国国务院发布了《节能减排综合性工作方案》,数据显示,中国不仅去年没有实现节能减排的目标,而且今年一季度,占全国工业能耗和二氧化硫排放近70%的电力、钢铁、建材、化工等六大行业增长20.6%,同比加快6.6个百分点。

中国钢铁业的能耗占到全球能耗总量的15%,是不折不扣的耗能大户。而Hismelt直接熔融还原炼铁技术的最大特点是直接将铁矿粉和普通煤粉,通过水冷喷枪吹到立式熔融还原炉内,通过一系列化学反应生产

产,设计年产能80万吨生铁,中国的首钢集团持有其5%的股份,其余三家股东分别是力拓集团、美国纽克公司和日本三菱公司。

作为一家传统的矿山企业,力拓公司在此时突然抛出Hismelt直接熔融还原炼铁技术,除了抓住中国政府渴望节能减排的迫切心情以外,更重要的是给自己在中国市场上留一条后路。

力拓公司是全球第二大铁矿石出口商,力拓铁矿拓展总裁沃维克·史密斯告诉记者,力拓计划未来的五六年内将把矿山的产量从2.2亿吨提高到5亿吨,其中所增产能的绝大部分是为中国市场准备的。

而中国的钢铁产量已保持了连年的高速增长,但所有人都相信在不久的将来这种状态将发生改变,而铁矿石的消费量将进入周期性放缓的阶段。为了应对这个早晚要出现的铁矿石供大于求的局面,力拓公司想出了一个“好”方案。

“我们可以免费提供这项技术,但前提是使用我们的铁矿石”,Hismelt公司负责市场营销的于永清先生告诉记者,中国的钢铁企业可以选择几种合作方法,可以和力拓签订长期铁矿石供货协议免费使用技术,或者根据购矿比例缴纳一定数额的专有技术使用费。

目前,国家发改委工业司的官员已经来此调研,首钢的曹妃甸新厂在二期规划中有可能应用此技术,宝钢也计划派出专家做三个月的技术跟踪,而中国的莱钢和准钢已经签署了



本报记者 勾新雨/摄

### 力拓中国谋划

- 1 累计投资10亿美元资金,研发能大幅节能减排的Hismelt技术,引起中国政府极大兴趣。
- 2 五六年内将把矿山的产量从2.2亿吨提高到5亿吨,其中所增产能的绝大部分为中国市场准备。
- 3 提出条件:免费提供这项技术,但前提是使用该公司的铁矿石。
- 4 过去一年,43家大型钢厂考察Hismelt奎那那工厂,一半以上来自中国。
- 5 首钢曹妃甸新厂二期规划可能应用此技术,宝钢也计划派出专家做三个月的技术跟踪,莱钢和准钢已经签署了技术合作协议。
- 6 首钢成为Hismelt炼铁技术的全球四家授权工程商之一。

Hismelt更吸引中国企业的是能够轻松地在还原炼铁过程中把磷脱掉。

去年,中国的武钢和首钢开始投入巨资争夺鄂西高磷铁矿,鄂西高磷铁矿发现于1959年,储量约22亿吨,属巨型铁矿,虽然早在上世纪50年代就发现了,但因该矿藏属高磷铁矿,由于技术原因,该矿一直未能大规模开采。

一旦Hismelt技术能够大规模应用,高磷矿就会身价倍增,成为中国钢铁业难得的矿产储备,首钢之所以与宜昌签约,投资80亿元开发高磷铁矿,看的就是未来的前景。

首钢股份公司的一位高层说,首钢一直对直接熔融还原炼铁技术感兴趣,曹妃甸的二期有可能会上一个炉子,而且是8米起步的,单个炉子年产200万吨以上。

于永清说,中国重钢、昆钢都对这项技术很感兴趣,因为他们都有高磷铁矿。

但也有专家对这项技术感到担心,中华商务网的马中普说,首钢在上世纪80年代在迁安搞过一个大厂,用的就是直接熔融还原炼铁技术,但技术没有突破。

马中普认为,直接还原炼铁技术即使成功也有一个缺陷,那就是需要生产出固体的生铁来,然后再加热进转炉炼钢,而目前国内都是先进的短流程生产工艺,高炉炼出的铁水直接进入转炉,生产线上根本看不到铁水。

Hismelt公司技术人员说,这种担心其实没有必要,现在Hismelt公司还是试生产状态,没有和下面的炼钢环节对接,所以生产的是铁锭,而对接

技术不会垄断中国钢铁业未来的高炉发展?

在去年的时间里,来Hismelt奎那那工厂考察的有43家大型钢厂,其中有一半以上是中国。对于中国的民营钢铁企业,这个技术的吸引力更大,因为民企新建钢厂很难获批,而应用了这个能够节能减排的技术就可以很轻松地获得国家发改委、科技部等部门的支持。目前,山东一家民营企业就在积极运作此事,新厂建设将有可能很快获得批准。

于永清说,我们的技术适用于三类企业,一是像宝钢、首钢这些大型国企,他们对节能和环保很看重;二是像重钢和昆钢这样的拥有高磷铁矿企业;三是一些中小的民营企业,通过先进的技术获得政府的建厂批准。

在此项目中拥有5%股权的首钢也暗藏野心,目前Hismelt炼铁技术采取授权工程商的方式来建造工程,全球只有4家授权工程商,其中中国只有首钢一家,也就是说无论未来有多少家企业准备建设Hismelt炼铁技术的铁厂,必须选择这4家中的一家进行核心技术的设计,可以预想这对首钢更多地参与国际高新技术的设计工作带来更多的商机,其中的巨大利润空间可想而知。

理论上,如果Hismelt炼铁技术在中国全面铺开,中国的钢铁厂就不需要焦炭了,山西遍地开花且污染严重的焦炭厂将面临灭顶之灾。

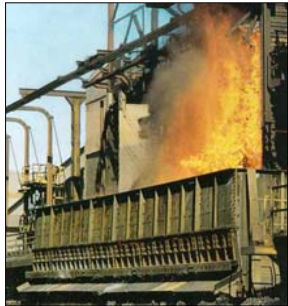
力拓集团北京代表处的经理宋秀丽认为这种担心没有必要,一种新的技术不可能完全替代旧的技术,两者在很

# A simple solution for iron-making in India

## Conventional Blast Furnace Technology



Sinter Plant – SO<sub>x</sub>, NO<sub>x</sub>, Dioxins, Furans



Coke Ovens – Tars, Phenols, PAHs



Blast Furnace – Molten Iron

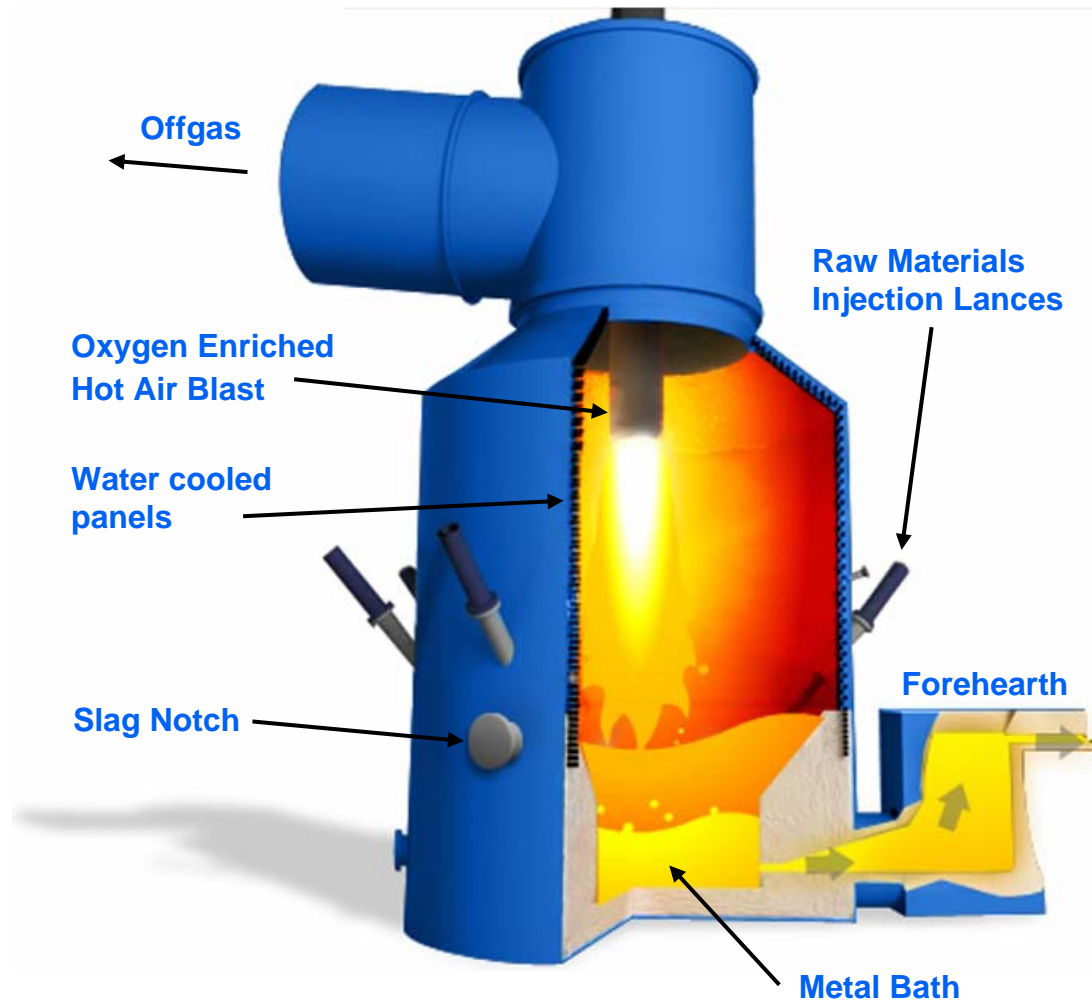


## Hismelt



Reduced capital cost, operating expenses & environmental impact

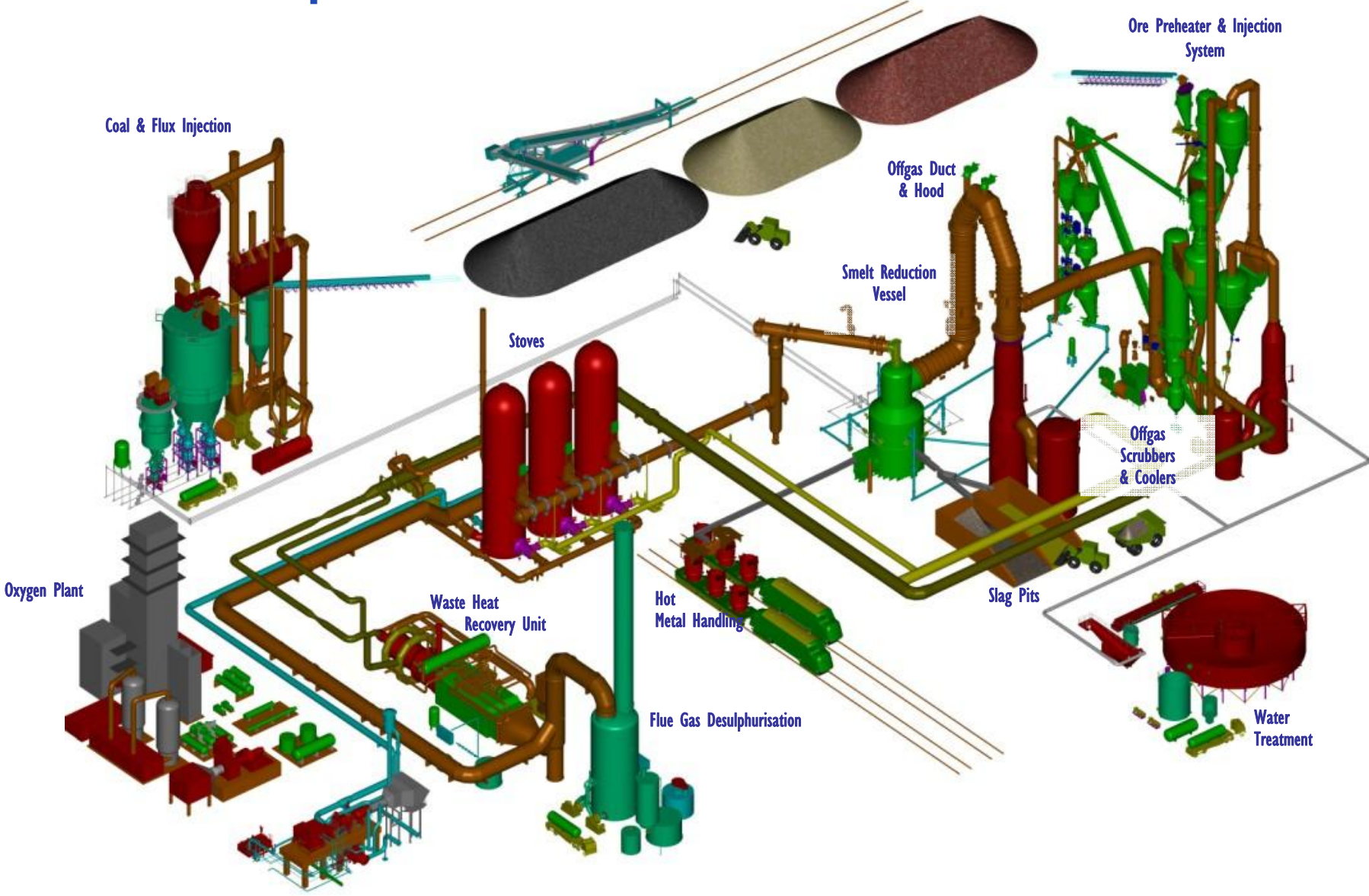
# The Hismelt process is simple



- Ore & coal are injected into the molten bath
- Hot blast is injected into the top-space
- Metal flows out continuously, slag is batch tapped

## Smelt Reduction Vessel (SRV)

# The Hismelt process is innovative



# Hismelt's Advantages for India

- Flexibility in Raw Materials
- Lower Capital & Operating Costs
- Lower Environmental Impact
- High Quality Iron Product



# Indian Raw Material Flexibility

## ■ Iron ore

- **Dry fines** (-6mm) and **slimes** (ultra-fines) – used directly
- High phosphorus content possible
- No blending or agglomeration necessary
- Can be pre-heated / pre-reduced to increase process efficiency



## ■ Steel plant wastes

- **Dry fine wastes** and **metallic fines** – used directly
- E.g. mill-scale, steel-making slag, reverts, coke breeze



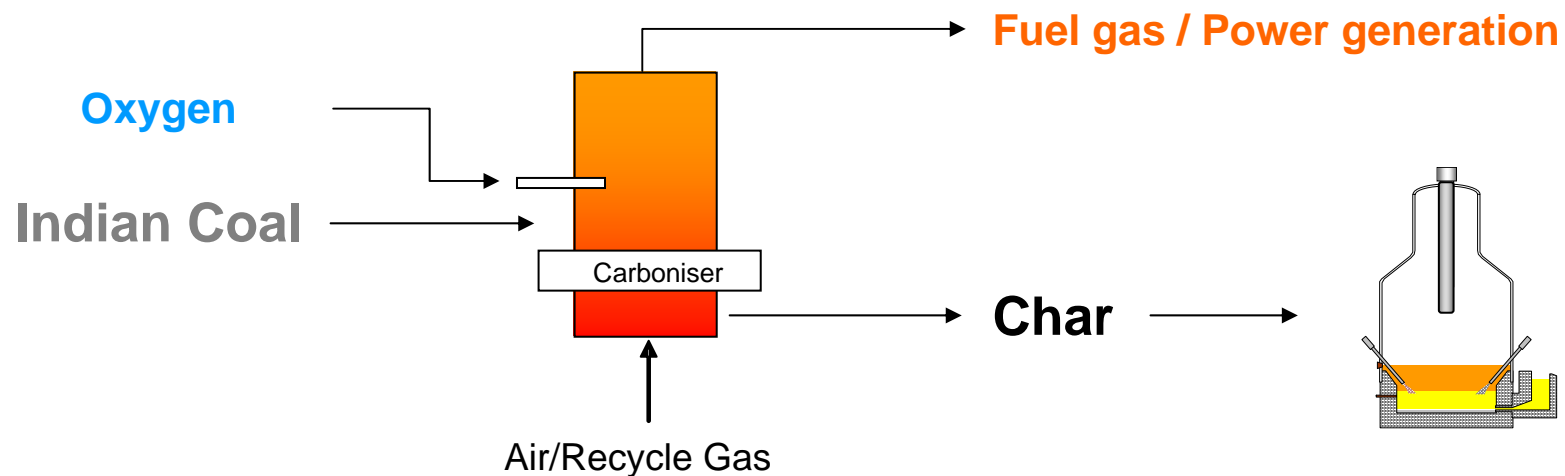
## ■ Coal

- **Non-coking coals** – ground to -3 mm and dried
- From coke breeze (low volatile) ⇨ high volatile thermal coal (40%)
- No blending, briquetting or coking required

# Higher Value from Indian Coals

- **Carboniser**

- Char = Rich carbon source for SRV
- Offgas used for power generation
- *Further investigation required*

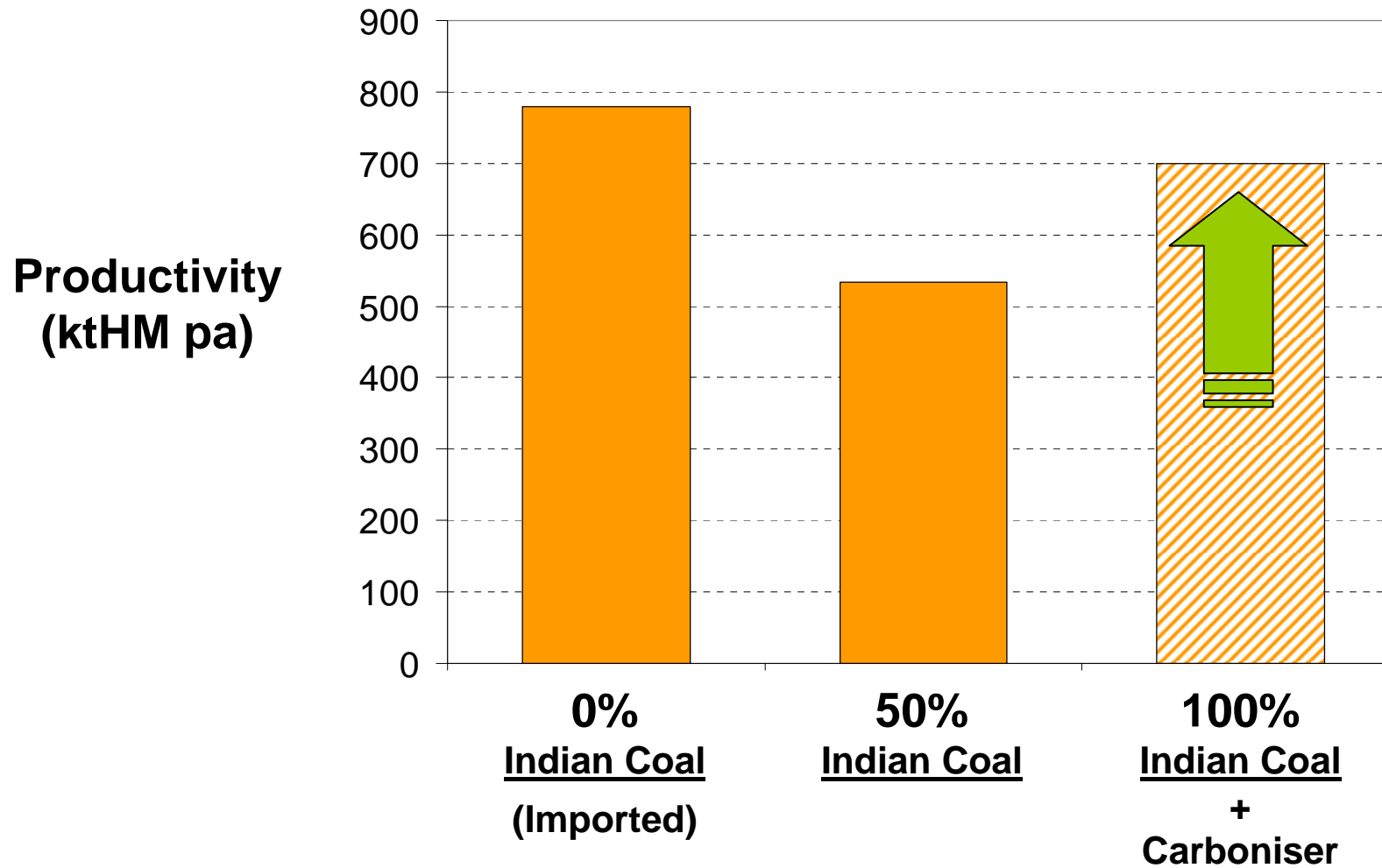


- **Circofer (after 2015)**

- Future technology using full spectrum of coals
- R&D in progress with Outotec (formerly Outokumpu/Lurgi)

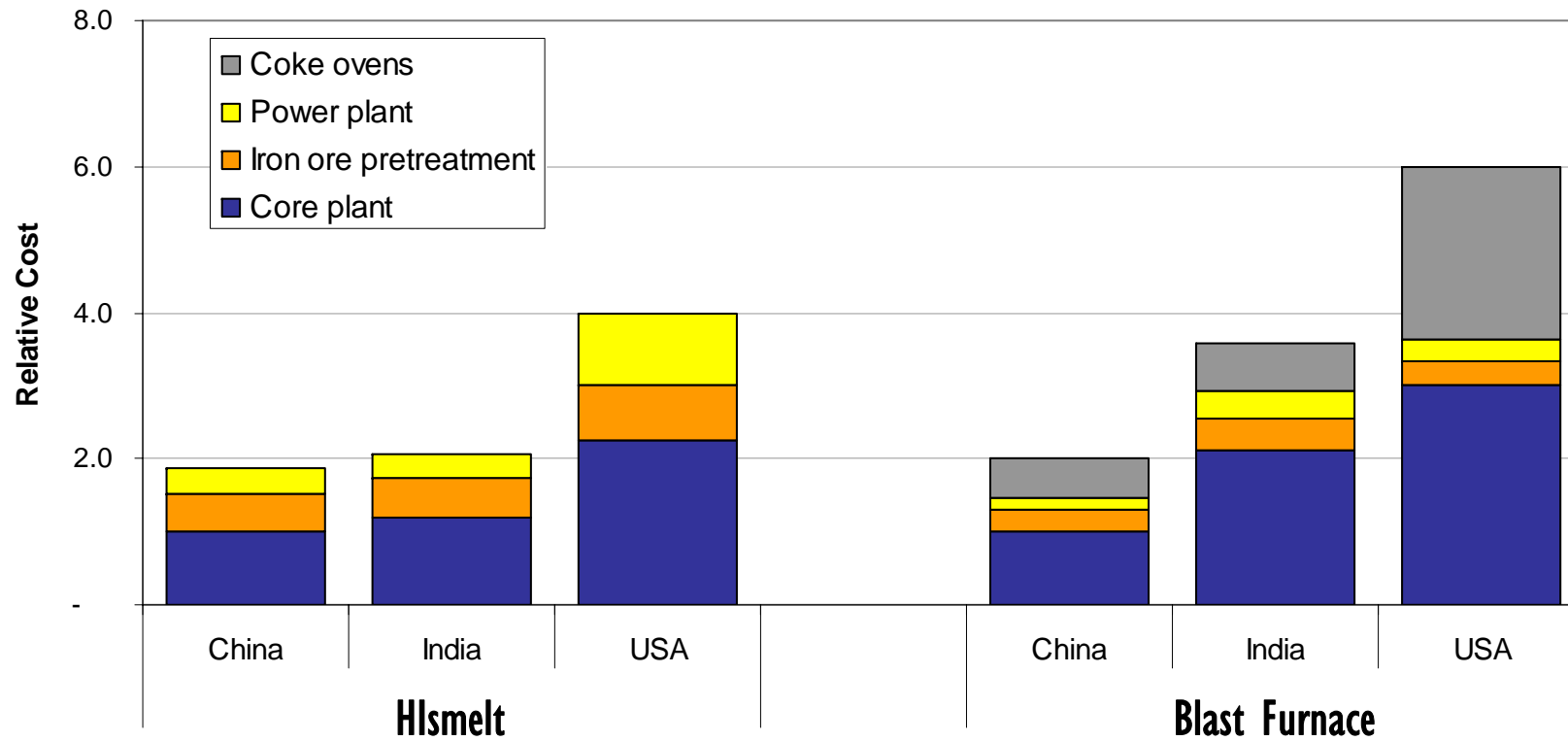
## Indian Coal Solutions:

- Use of a carboniser will allow higher productivity to be achieved with local coals



\* Assumes use of: Local Indian coal containing 18% ash and 25-30% volatile matter; Imported coal containing 10% ash and 10% volatile matter

# Lower Capital Cost for Greenfield Expansions



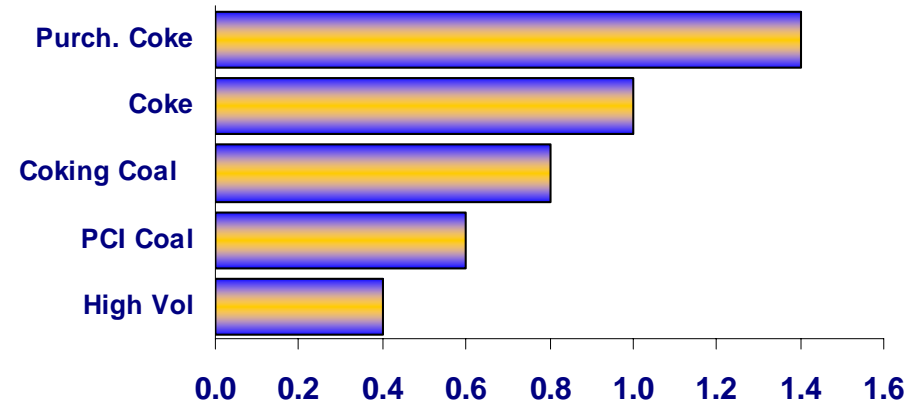
2Mtpa Greenfield Facility Comparison

Source: Rio Tinto analysis; 2006

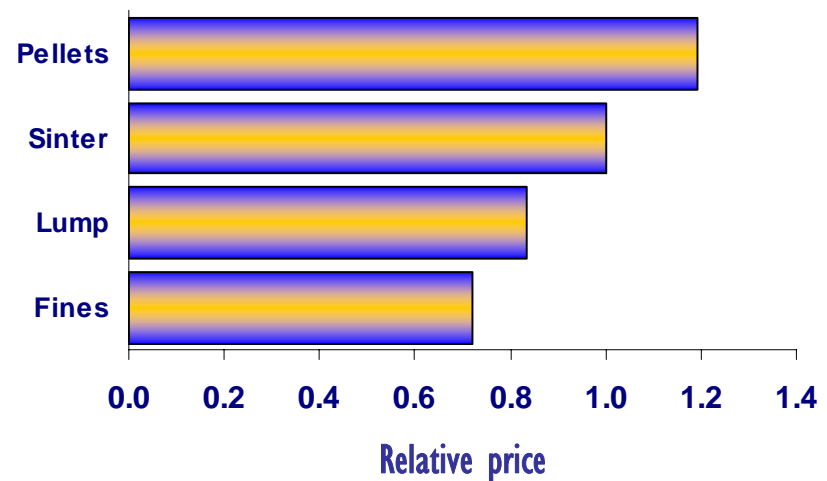
# Lower Operating Costs: Lower input costs

- Non-coking coals
- Iron ore fines
- Single source feeds okay
- No need for blending yards

Reductants

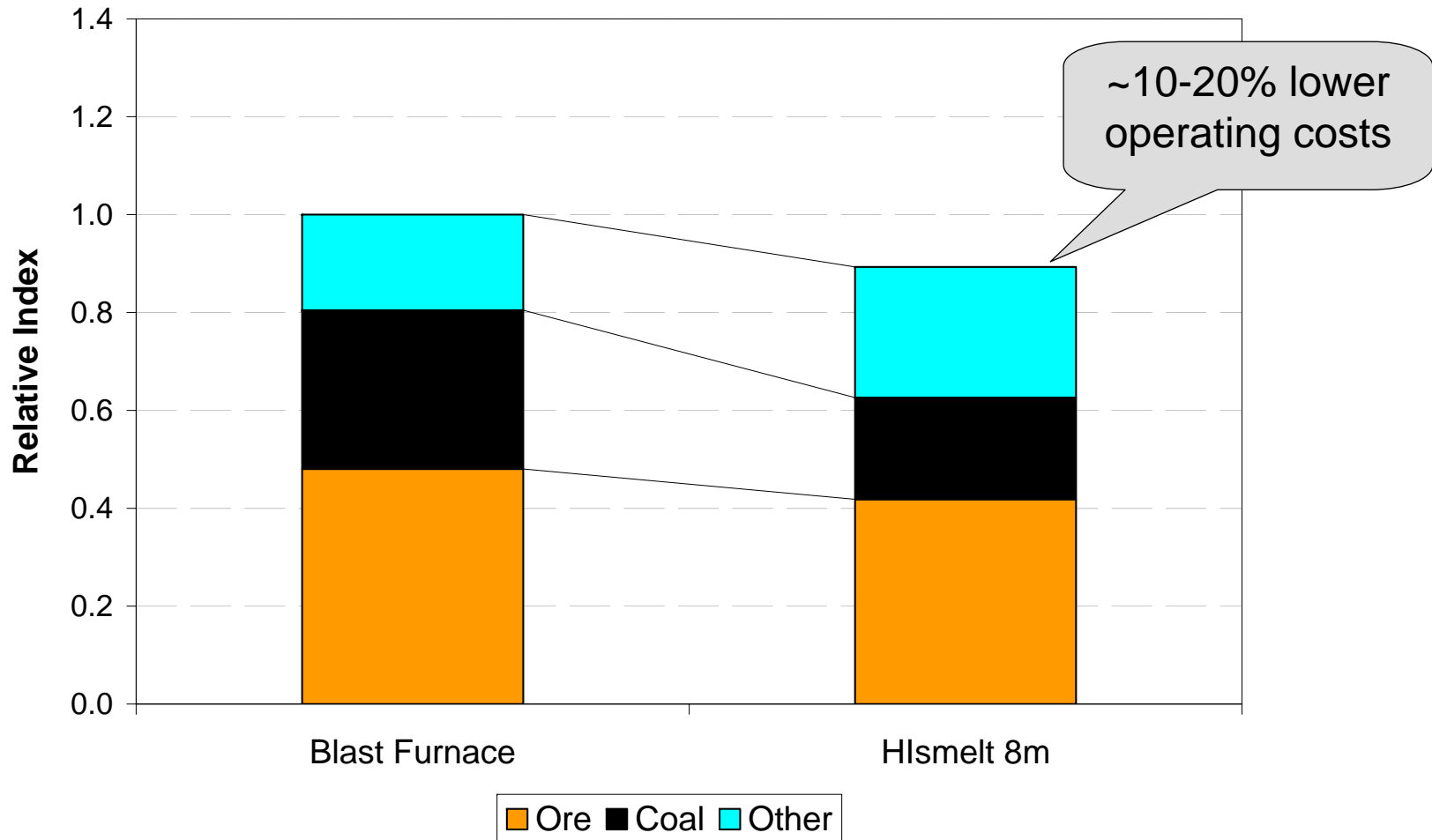


Iron Units



- Graphs are indexed values only on a per tonne basis
- Source: CRU averages (updated Jan 2008)

# Lower Operating Costs: Compared to blast furnaces



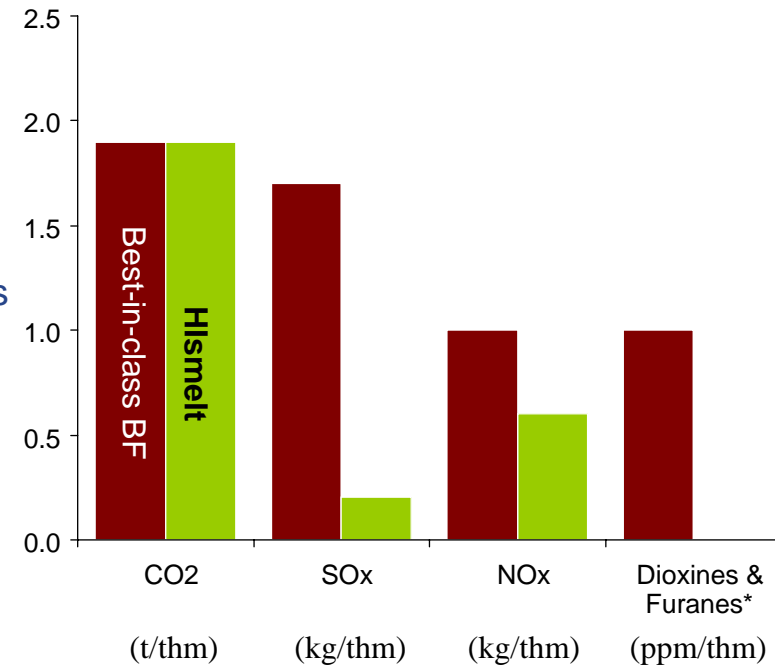
Source: Rio Tinto analysis

# Lower Environmental Impact

- **Recycle Wastes**
  - Utilise iron ore slimes
  - Steel plant wastes
  - Other iron unit sources (e.g. steel-making slag)
- **No Toxic Emissions**
  - No dioxins, furans, phenols or tars
- **Reduced Overall Emissions**
  - Reduced CO<sub>2</sub>, SO<sub>2</sub> and NO<sub>x</sub>
  - CO<sub>2</sub> Emissions
    - Now in line with BF
    - Future plants (Circofer) → reduced emissions
    - Circofer CO<sub>2</sub> can be sequestered
- **Low Footprint**
  - Less land disturbance
  - Power balanced




Emissions per thm



Source: Rio Tinto analysis

## Higher Quality Iron: Compared to blast furnaces

Typical Analysis	Blast Furnace	 Hismelt
Carbon	4.5%	4.4 ± 0.15%
Silicon	0.5 ± 0.3%	<0.01%
Manganese	0.4 ± 0.2%	<0.02%
Phosphorus	0.09 ± 0.02% *	0.02 ± 0.01% **
Sulphur	0.04 ± 0.02%	0.1 ± 0.05% #
Temperature	1430 - 1500°C	1420°C

# Dependant on sulphur input (mainly from the coal). With hot metal de-sulphurisation treatment (known technology) sulphur levels are easily able to be reduced to <0.05%.

\* Low Phosphorus Ore

\*\* High Phosphorus Ore

Hismelt 2007 metal quality

# Hismelt Kwinana Plant Update



# First Hismelt Commercial Facility

- Located in Kwinana, Western Australia
- Capacity of 800,000tpa
- High quality merchant pig iron


- Experienced Joint Venture Partners:

- Rio Tinto           60%
- Nucor               25%
- Mitsubishi       10%
- Shougang         5%



**RIO  
TINTO**

**NUCOR**

 **Mitsubishi Corporation**



# Path to Operation

- **Construction**
  - Started January 2003
  - Completed April 2005
  
- **Hot commissioning / Initial operations**
  - May-September 2005
  
- **Operation**
  - 3 year ramp-up period beginning in November 2005
  - Ramp-up schedule:
    - 50% nameplate by 2006
    - 80% by 2007
    - 100% by 2008



# Core technology is working well at commercial scale

- **SRV close to design rates, reached ~80tph (77% of nameplate)**

- Flue Gas De-sulphurisation (FGD) capacity limited productivity to ~60%
- FGD capacity upgraded in July-07 and new production records were set:
  - 1,700t in a day
  - 9,600t in a week
  - 30,000t in a month

- **Coal consumption has fallen to 810kg per tonne**

- on track for <700kg/tonne\*

- **Producing a premium grade product**

- Very low levels of P, Mn, Si
- Low sulphur after desulphurisation
- Able to handle high P and high Al ores

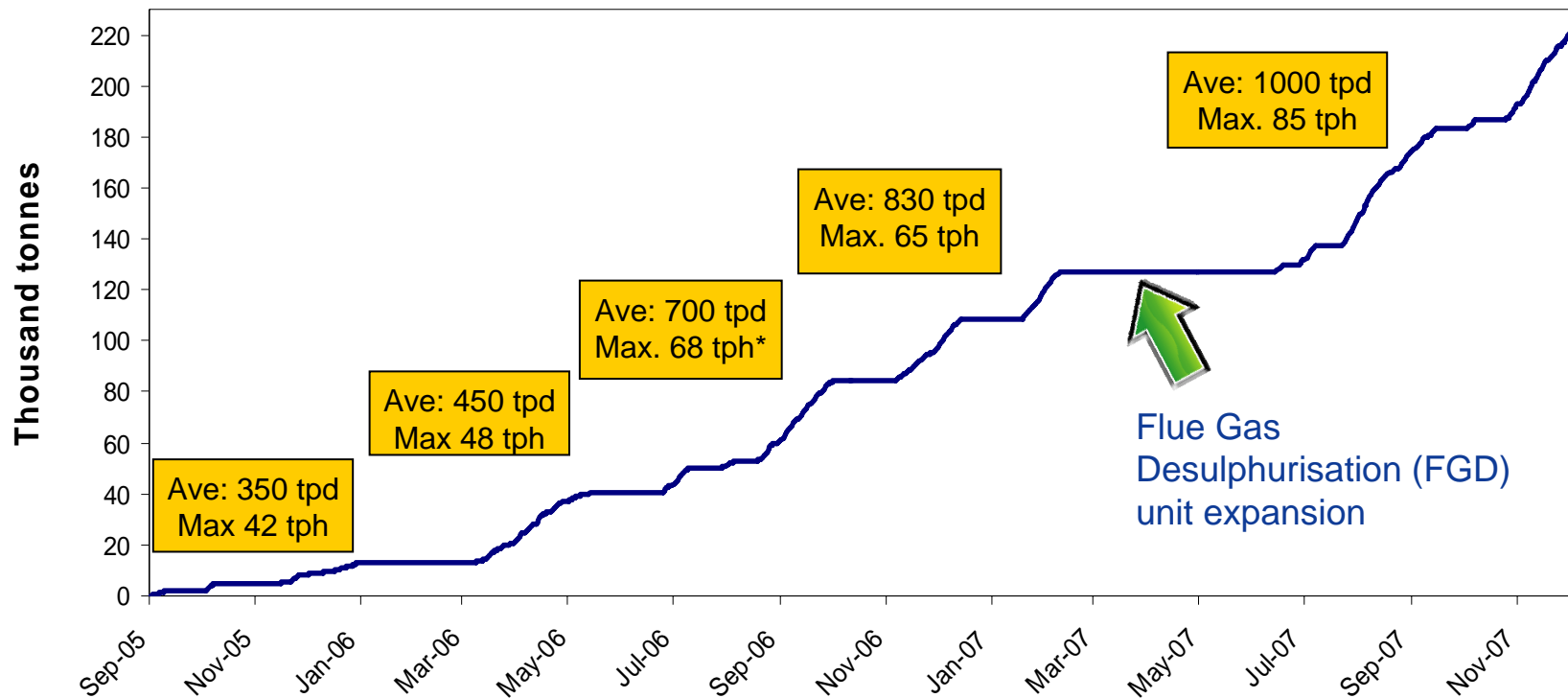


\* On a dry basis

# Cumulative production

– Improving as bottlenecks removed

## Accumulated Hot Metal Production

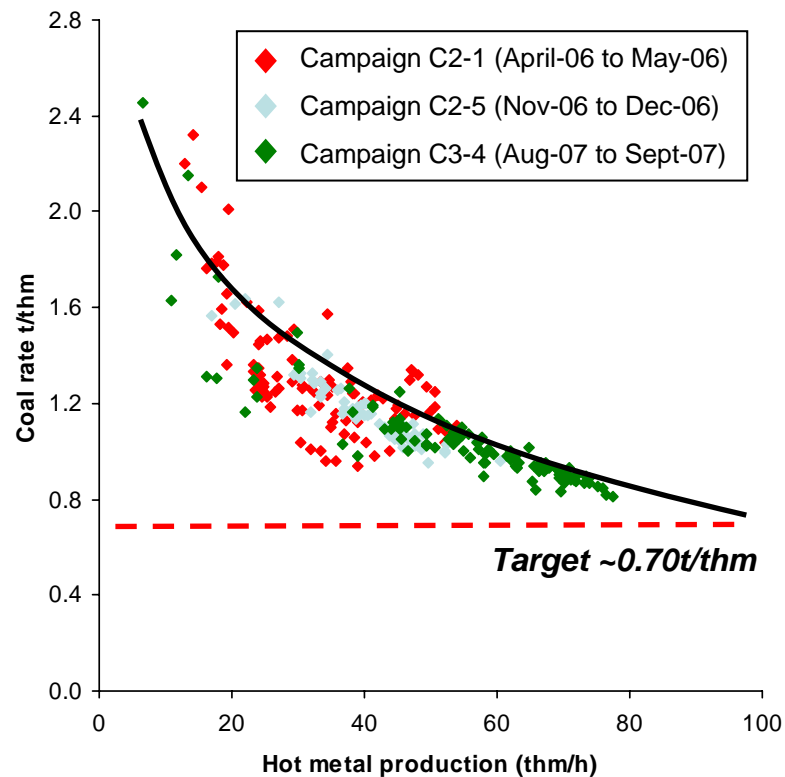


•This maximum rate exceeded the capability limit of the FGD, and practical maximum production rate was 65 t/h until extra FGD capacity was added in 2<sup>nd</sup> quarter 2007

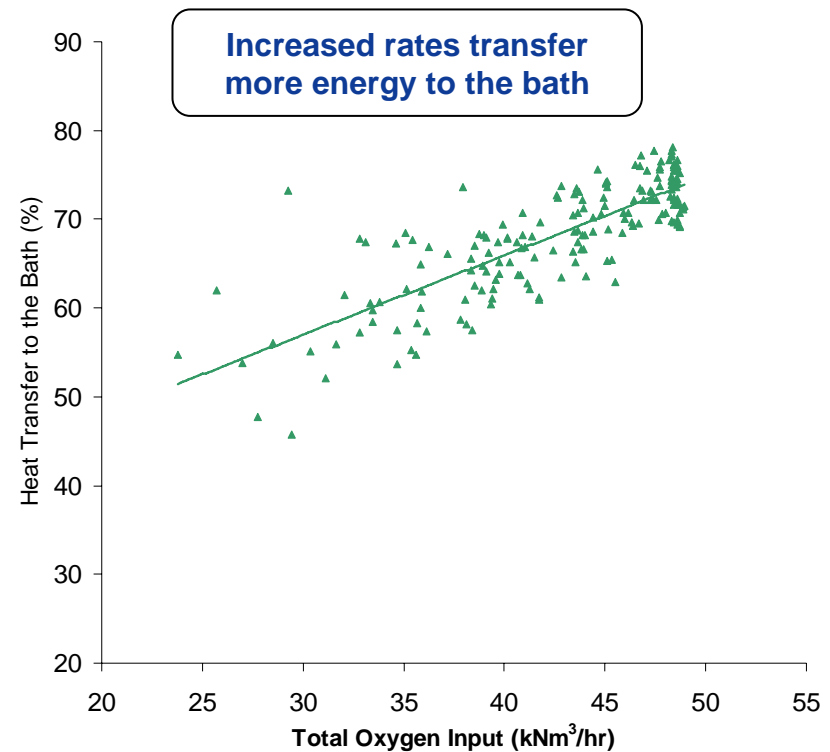
•Source: Hismelt Operation

# Hismelt Process indicators are excellent

## Coal rate (t/thm)



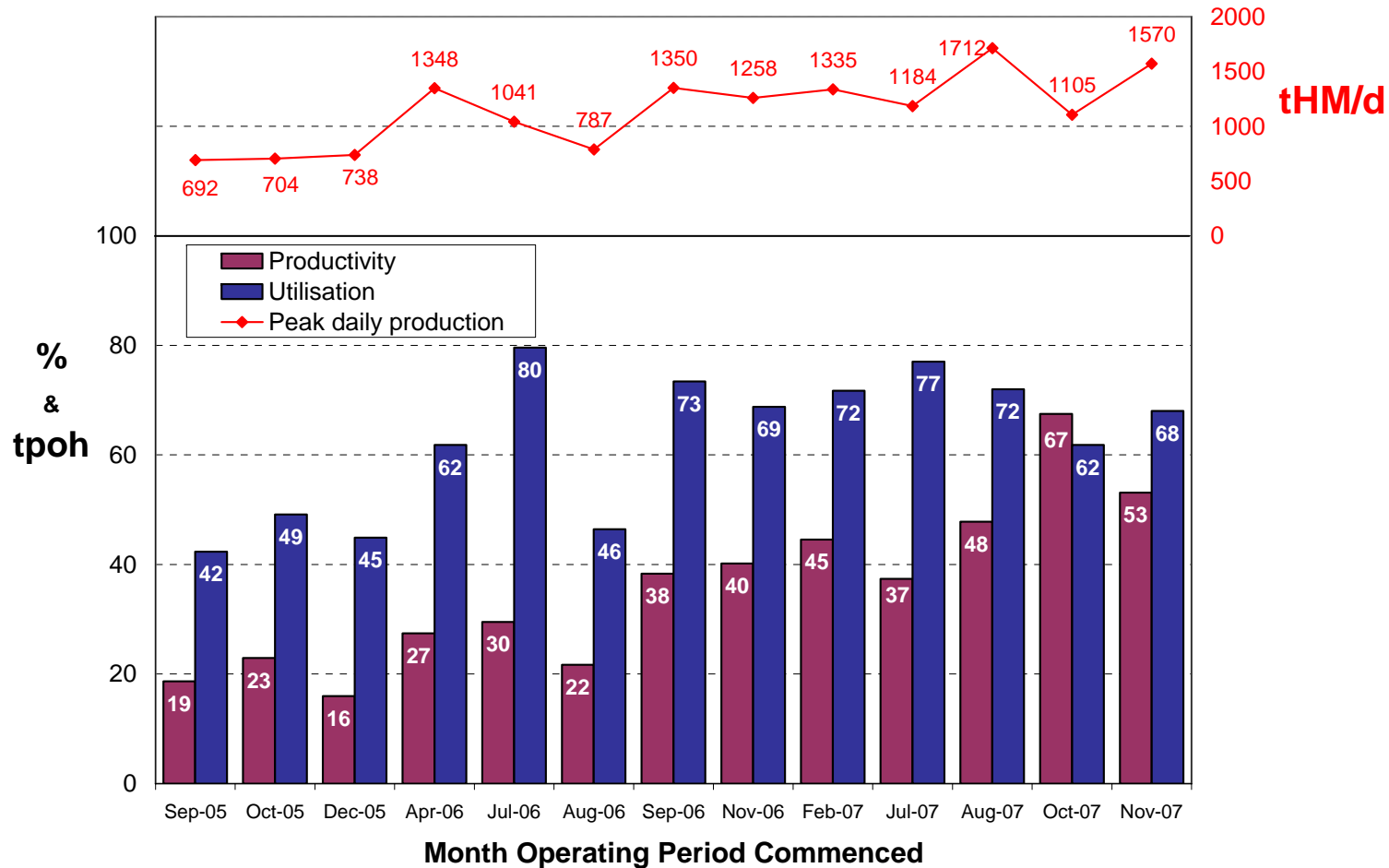
## Heat Transfer Efficiency (%)



•Source: Hismelt Operation

# Performance by Operating Period

## – Productivity and Utilisation Steadily Increasing



**Key**

Productivity = Average productivity when injecting ore (tonnes per operating hour)  
 Utilisation = Time that ore was injected (%)

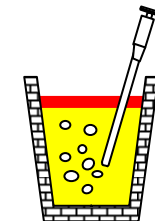
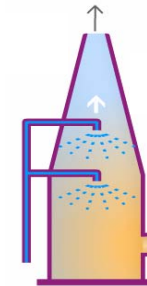
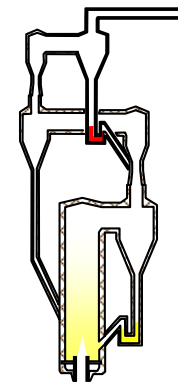
•Source: Hismelt Operation

# Commissioning issues being systematically eliminated

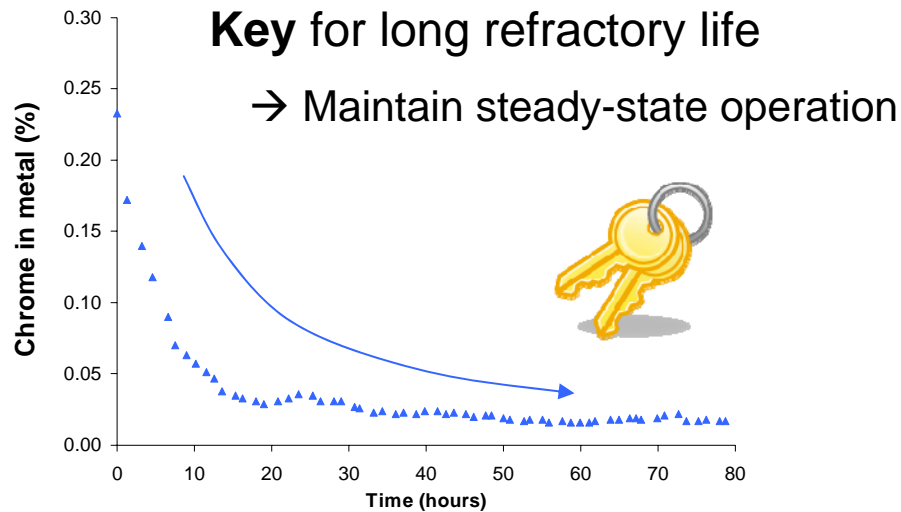
- **Reliability issues have limited Kwinana Hismelt Plant production**
  - E.g. 30+ interruptions to ore injection for December '07

- **Significant causes of delays been:**

- **Preheater** - Refractory sub-optimally installed (rectified)
  - Unreliable ore feed system (rectified)
- **WHRU** - Process control / reliability (rectified)
  - Trips (50+) stop whole plant...
    - Integrated steam systems (Blower, Oxygen plant)
    - Will be replaced with electric drives next plant
- **Flue Gas Desulphurisation**
  - FGD unit under-designed (rectified)
- **Hot Metal Handling**
  - Desulphurisation & Pig Casting integrated with the SRV
    - Delays could quickly create a bottle-neck
    - Hot metal for steelmaking in future plants

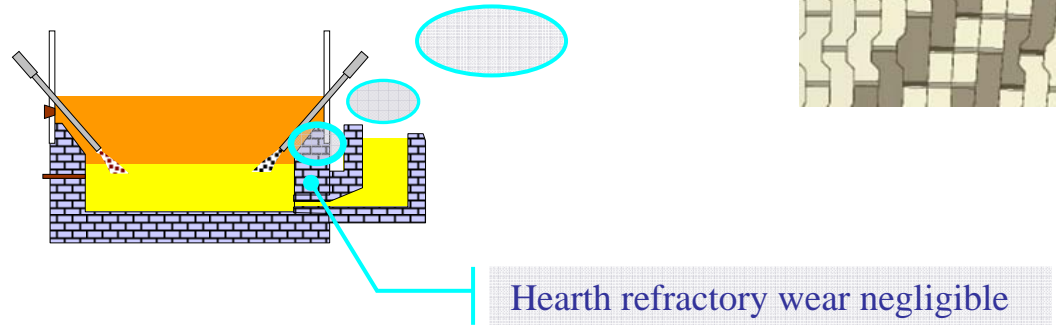


# Refractory wear falls dramatically when the plant is running steadily




Slag Zone improvements:

- Slag zone coolers
- Keyed refractory bricks



•Source: Hismelt Operation

## Key Plans for 2008

- 
- **Optimise SRV to achieve 80 → 100tph**
  - **Focus on improving plant reliability / availability**
  - **Extend SRV campaign life**
    - Installation of slag zone coolers
    - Installation of keyed SRV refractory bricks
  - **Couple Preheater to SRV**
    - ~10% pre-reduction / Productivity increase

# Future Technology Developments



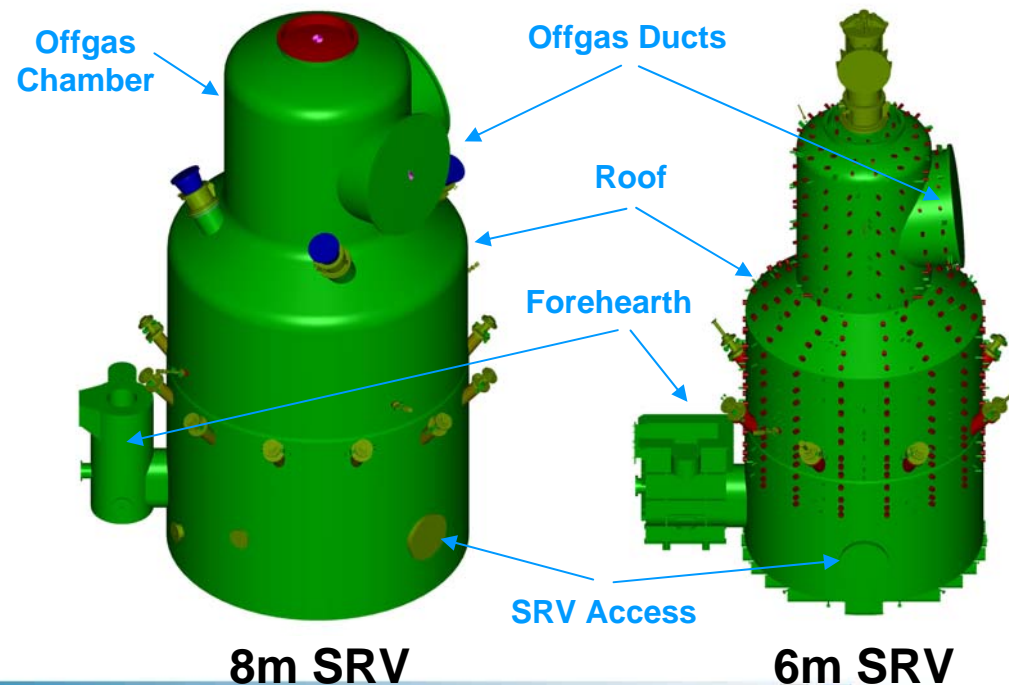
# The Next Step: 2Mtpa – 8 metre diameter SRV

## Major Changes from 6m SRV

- Hearth diameter from 6m to 8m
- Production from 0.8 to 2.0 Mtpa
- Redesigned hot air blast injection – improved process efficiency, simpler manufacture
- Two 6m offgas hoods – single larger hood not feasible to manufacture, transport or erect

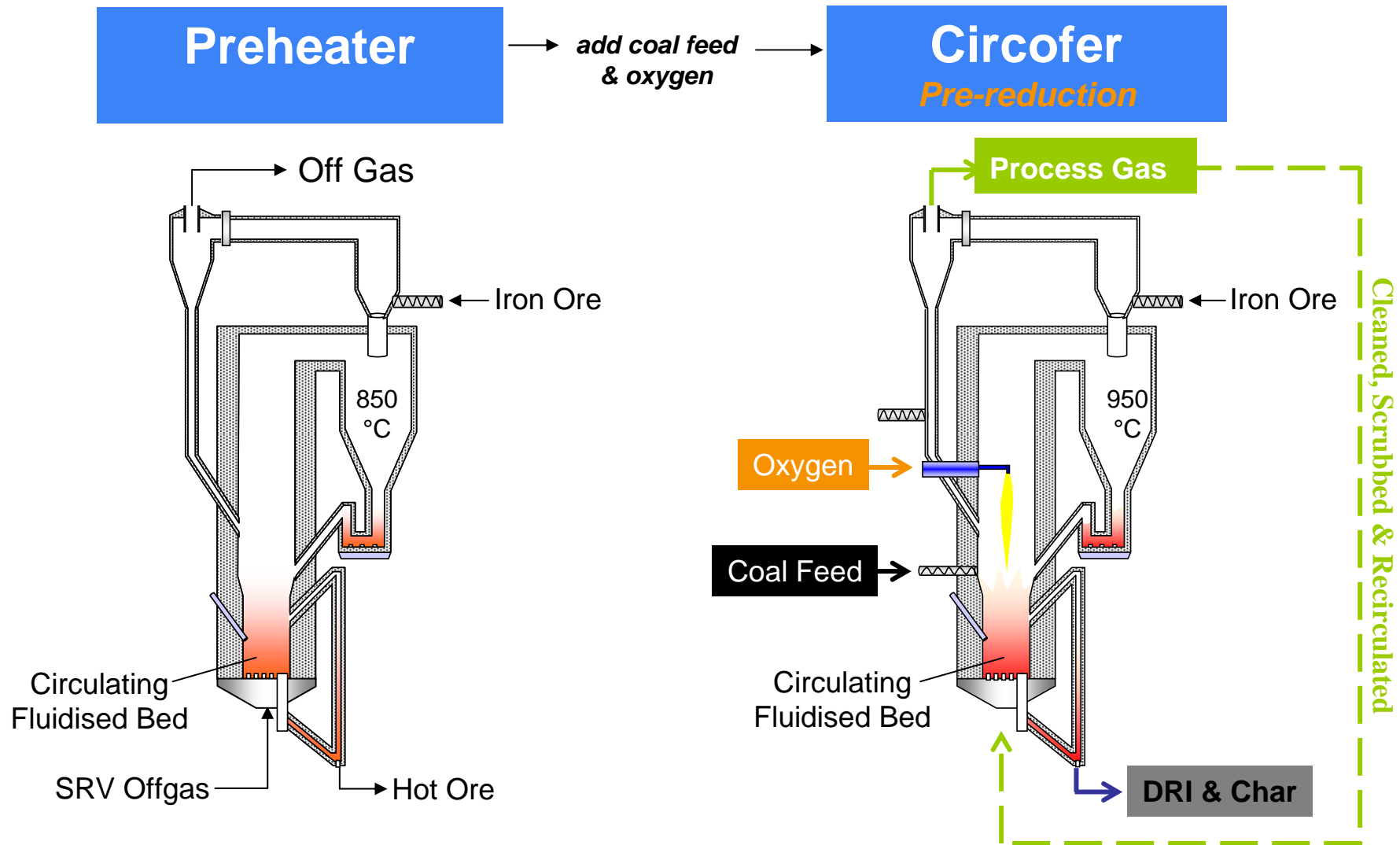
## Minimal Changes to:

- Lances
- Forehearth
- Cooling Panels
- Refractory



# Circofer

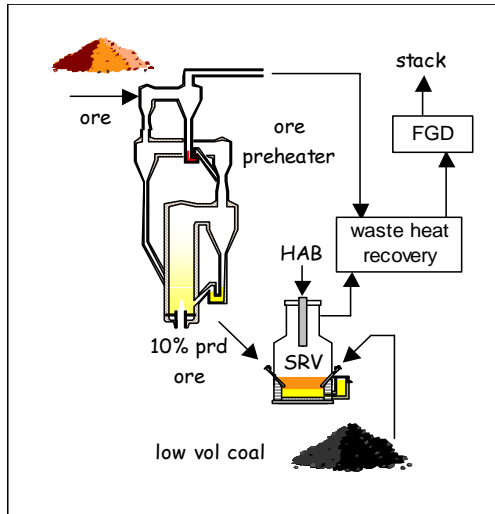
– Utilising full spectrum of coals & dramatically lowers CO<sub>2</sub> emissions



\* Circofer is a trademark of Outotec GmbH

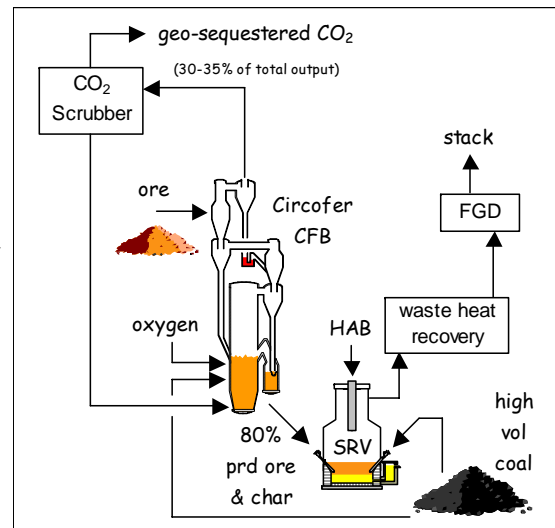
# Future developments will allow major reductions in GHG

**Hismelt Mark I (2008)  
Kwinana Plant**



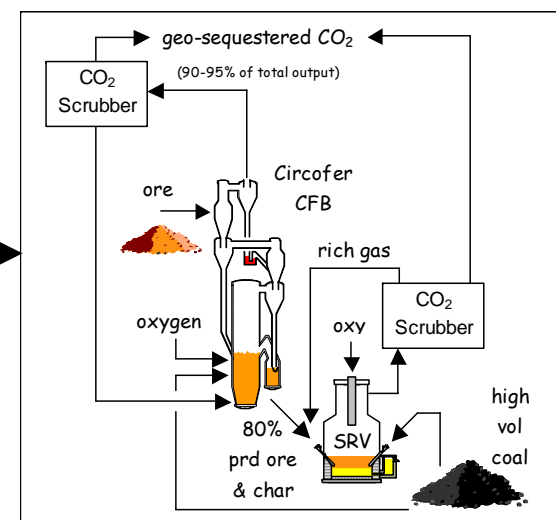
**CO<sub>2</sub> Emitted**  
1.7-1.9 t/thm  
*Equal to world's best blast furnace*

**Hismelt Mark II (2010)  
Circofer**



**CO<sub>2</sub> Emitted**  
0.9-1.1 t/thm  
**50% reduction**

**Hismelt Mark III (2012)  
N<sub>2</sub>-Free + Sequestration**

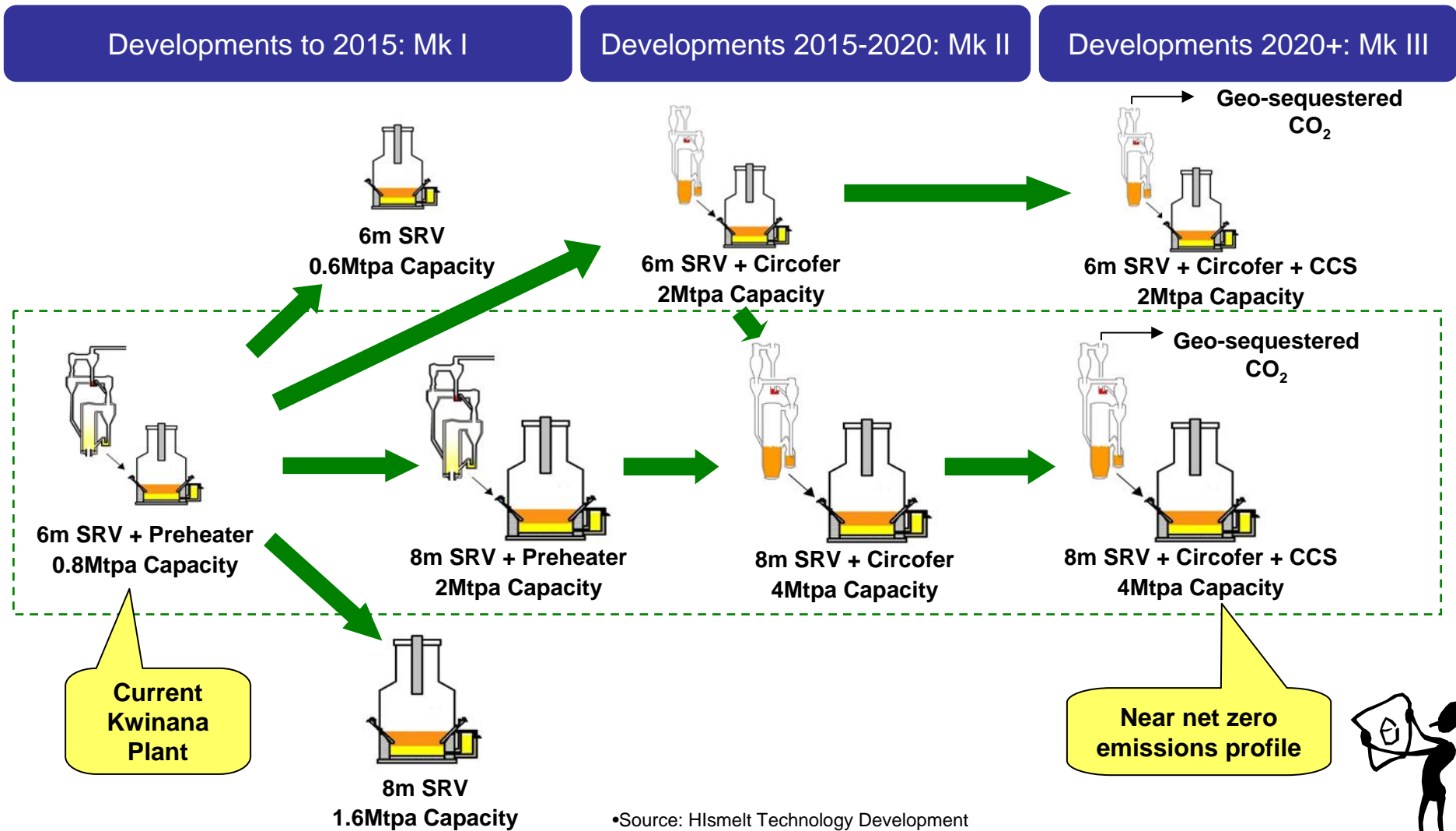


**CO<sub>2</sub> Emitted**  
0.1-0.3 t/thm  
**90% reduction**

•Source: Hismelt Technology Development

# Hismelt's Technology Roadmap:

– Step change improvement in capacity and emissions



•Source: Hismelt Technology Development

## In Summary

- **The Hismelt process is performing. Production achievements of:**
  - 30,000t in 30 days
  - 9,600t in 1 week
- **Coal rates on track with design**
- **Strong global interest in the technology**
  - The 3 top politicians in China have visited Kwinana
  - Over 80 steel company visits
- **Increasing injection & production rates to nameplate capacity in 2008**
- **Detailed engineering for 2Mtpa Hismelt plant complete**
- **Circofer pilot plant test-work nearing completion**
  - Pathway to lower CO<sub>2</sub> emissions
- **Preparing to deliver raw material flexibility to India...**

