Recent technological advancements in high capacity pellet plants

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Karl-Heinz Hofmann – Outotec, Brazil

Outotec

Agenda

- Outotec and Samarco in brief
- Industry megatrends and drivers
- Outotec technological advances
- Samarco 4 case study
- Summary

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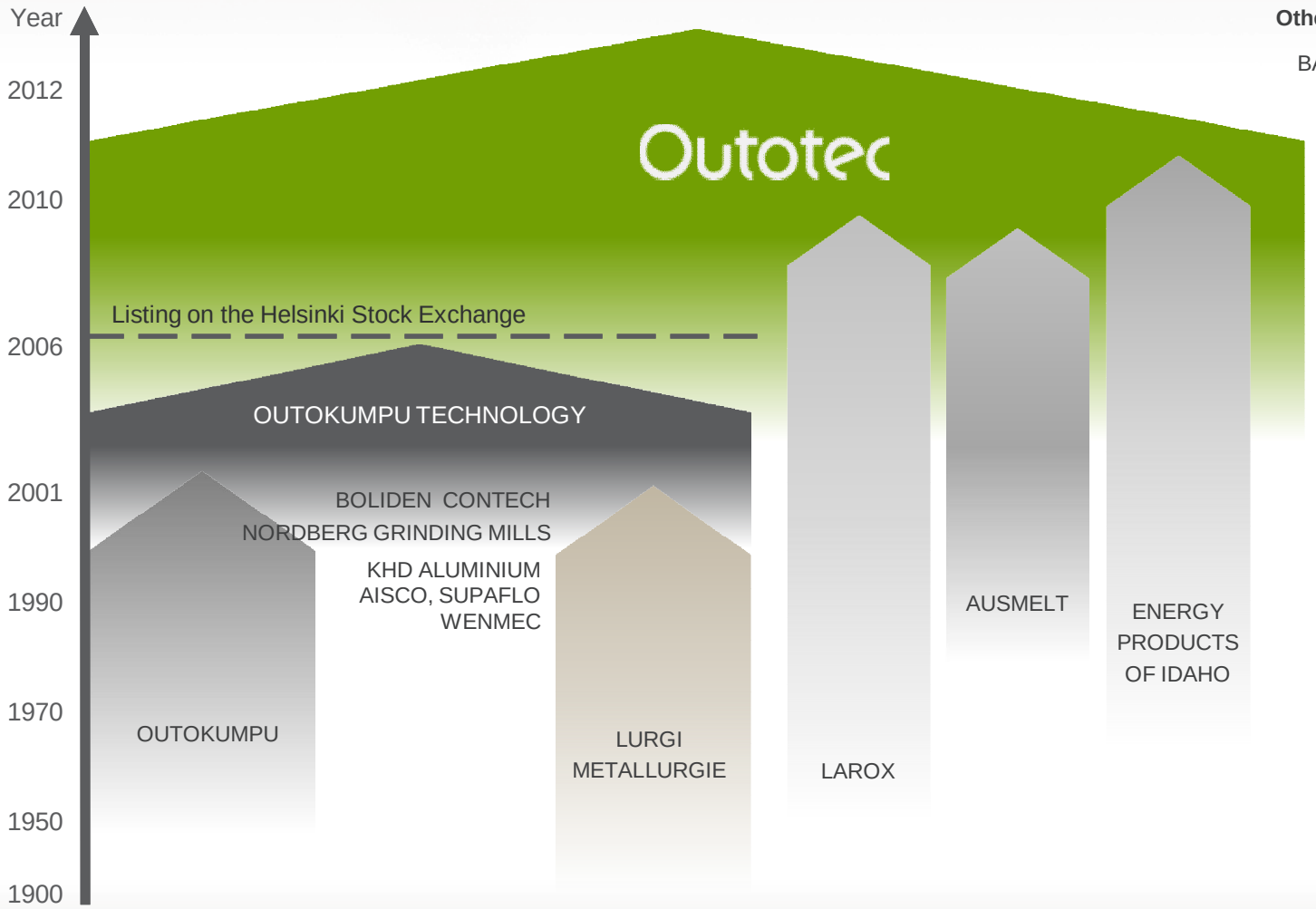
A technology leader for over a century



Other recent acquisitions:

BACKFILL SPECIALISTS
TMS GROUP
DEMIL MANUTENÇAO
NUMCORE
KILN SERVICES
VPF, ASH DEC
MILLTEAM
EDMESTON
AUBURN

Four business areas providing sustainable solutions

Ferrous Solutions

For processing iron ores and other ferriferous materials in the entire value chain from ore to metal

Non-ferrous Solutions

For processing copper, nickel, zinc, lead, gold, silver and platinum group metals in the entire value chain from ore to metal

Energy, Light Metals and Environmental Solutions

For sulfuric acid production, off-gas handling, alumina refining, roasting, calcining, biomass, oil shale and oil sands processing as well as industrial water treatment

Services

Providing life cycle services to Outotec's customers

Life cycle solutions creating best value to customers

Conceptual design

- R&D services
- Modeling & simulation
- Testwork
- Feasibility studies

Engineering and supply

- Flowsheet development
- Basic/detail engineering
- Supply of process and plant equipment
- Operability & maintainability optimization
- Spare parts

Construction and commissioning

- Plant construction
- Equipment installation
- Start-up and ramp-up services
- Training

Operation and maintenance

- Plant operation
- Spare parts
- Preventive maintenance
- Auditing
- Testwork
- Shutdown services
- Equipment life assessment
- Upgrades
- Process optimization
- Modernizations
- Training

Decommissioning

- Refurbishment of equip. for re-use
- Plant decommissioning
- Permanent shutdown of the plant
- Land reclamation

WE ARE SAMARCO.

A BRAZILIAN COMPANY THAT SUPPLIES IRON ORE TO THE WORLD STEEL INDUSTRY.

- Founded in 1977
- **Eighth largest exporter in Brazil,** pursuant to the Foreign Trade Department of the Ministry of Development, Industry and Foreign Trade (January 2013)
- **Second largest supplier** of iron ore pellets on the seaborne market (2012)
- Private company, controlled in equal parts by two shareholders: Vale S.A. and BHP

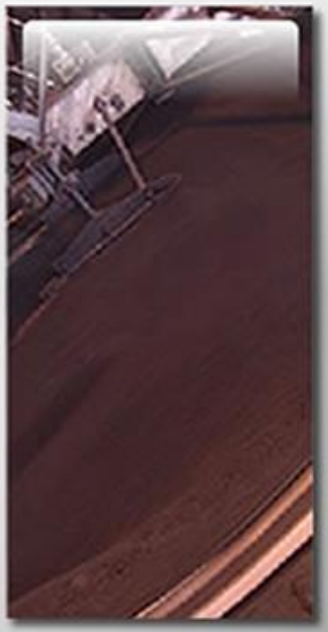
INTEGRAD PRODUCTIVE PROCESS

SAMARCO

MINING

CONCENTRATORS

PIPELINES



PELLETIZING UNITS

PORT FACILITIES

LOCATION


BRASIL
NOVA ERA – ANTÔNIO DIAS
(Guilman-Amorim Hydroelectric Plant)
BELO HORIZONTE
(main offices)
ESPÍRITO SANTO
MARIANA – OURO PRETO
(Germano operational unit)
ANCHIETA
(operational unit and Ocean Terminal at Ponta Ubu)
MUNIZ FREIRE
(Muniz Freire Hydroelectric Plant)

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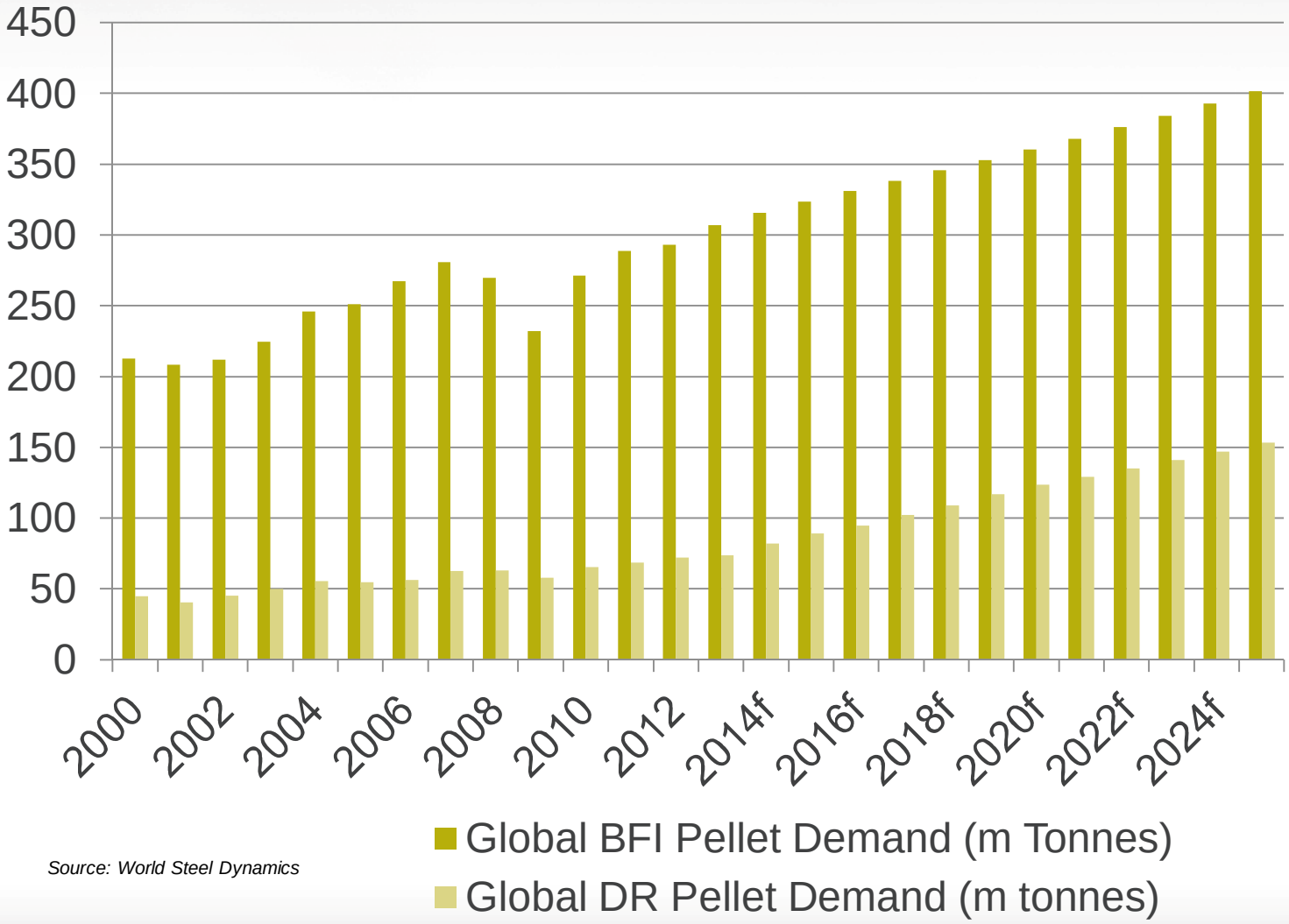
Industry megatrends



Source: World Steel Dynamics

Industry trends - demand for sustainable technology

Ore grade

Ore grades are declining and in order to meet the increased demand, more ore needs to be processed with more advanced technology.

Energy

Making metals requires a lot of energy and energy costs are constantly climbing. More energy-efficient processes are needed.

Emissions

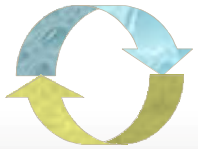
Mining and metallurgical industries are major emitters of CO_2 and ecotoxic substances. Cleaner solutions must be developed.

Water

Water availability and pollution are critical issues. Advanced solutions for water cleaning, conservation and recycling are needed.

Oil peak

Oil peak is approaching. Oil is expected to run out by 2050 with current production rates, thus alternative sources are needed.



Recycling

The need for recycling is growing, thus requiring new technologies for turning scrap and waste into products.

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Introduction

- Two industrial systems dominate the iron ore pelletising industry
  - Outotec's travelling grate (accounting for over 2/3 global production)
  - Grate-Kiln pelletising system
  - Note: low capacity shaft furnaces have only regional relevance
- The Outotec travelling grate is unique
  - Plant capacity available from 1.0 to 9.25 Mtpy in a single machine
  - Market leader and capable of handling all types of iron ore
    - Magnetite, hematite and weathered ores
- Outotec has installed 46 pellet plants around the World
  - Ongoing development of the technology by Outotec continues with the most experienced pellet plant operators in the World
    - LKAB, Vale and Samarco
- Extensive Research and Development facilities in Frankfurt, Germany
  - In house R&D providing leading edge design concepts for the future
  - Specific process solution solving for our global customer base

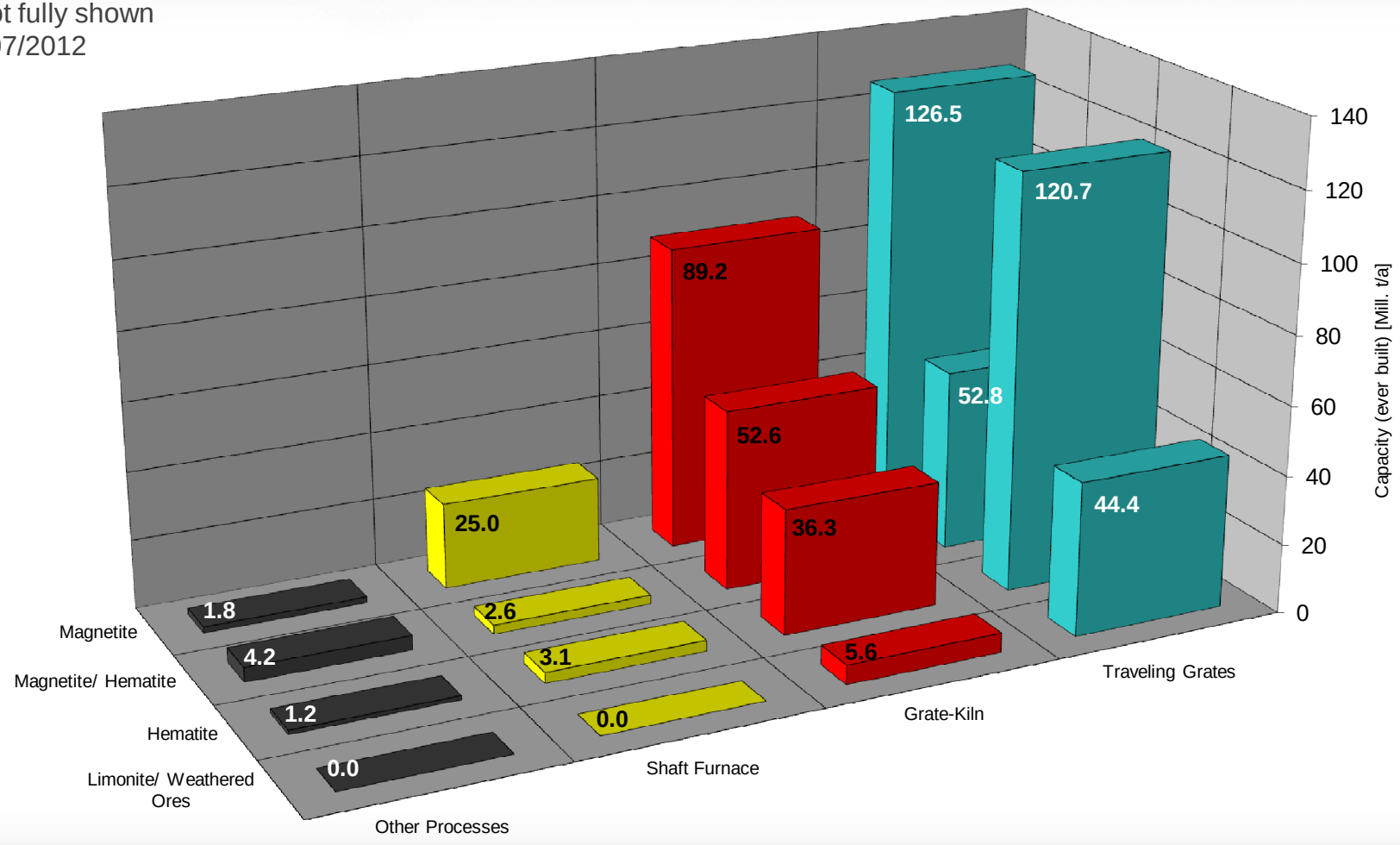
High plant availability

- One straight grate indurating machine versus the Grate Kiln's three "in line" processes leads to significant upsides, proven in plants designed/built by Outotec:
  - Plant availability
    - Design: 330 - 345 days/year
    - Achieved: up to 355 days/year
  - Plant operating campaigns
    - Planned: > 2 years
    - Achieved: > 5 years
- A travelling grate reference in Europe recently concluded a ten year campaign without major shutdown!

- Outotec travelling grates machines result in significant increases in plant production and reduction of operating expenses

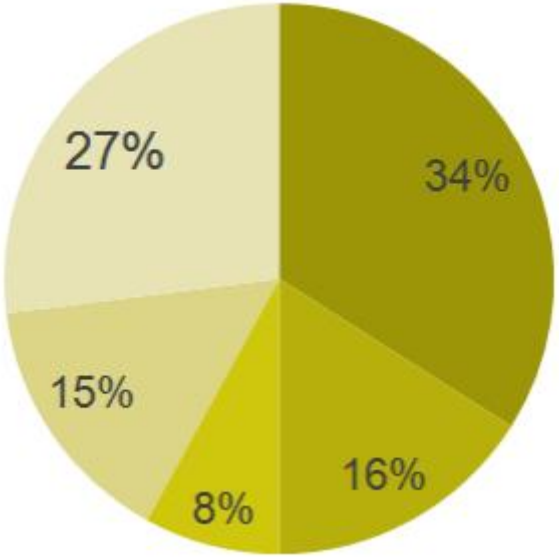
Raw Material Flexibility

Pelletizing capacity ever built
China not fully shown
Status: 07/2012

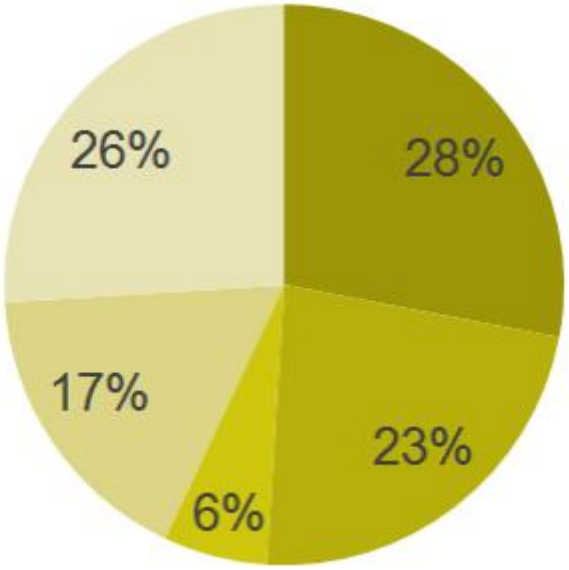


Recent/future production capacity development

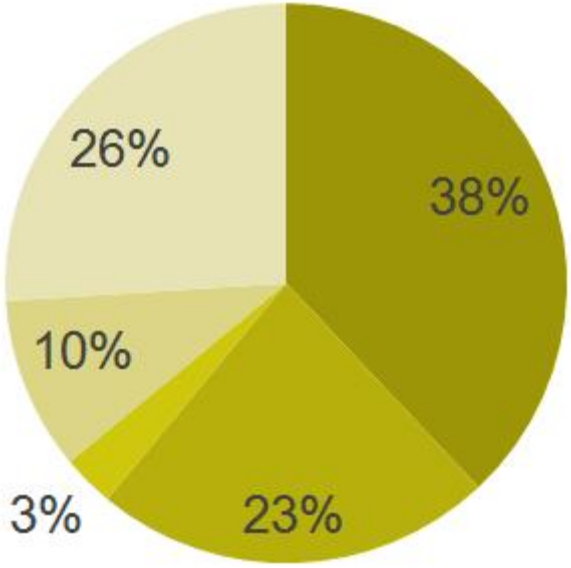
2002 – 2012:
124.5mtpy



2008 – 2012:
86.6mtpy



2008 – 2015:
156.9mtpy



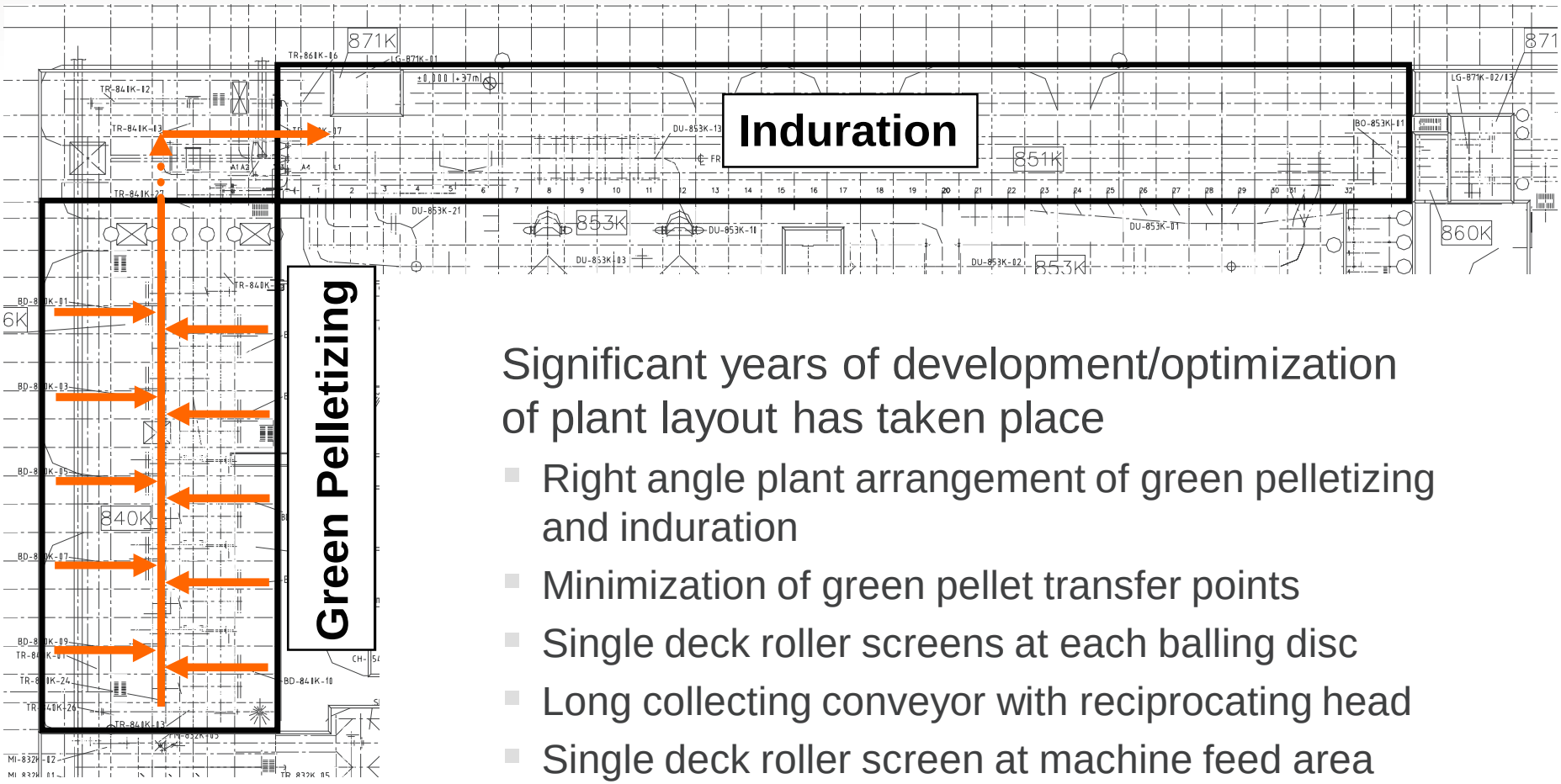
- Outotec travelling grate
- Metso/Dravo travelling grate
- Metso/Allis Chalmers grate kiln
- Kobe Steel travelling grate
- Others

Dedicated in-house R&D facilities

In-house test facilities and the associated knowledge/expertise for testing representative iron ore samples and analysing results in order to offer tailored process plant solutions and the prerequisite process guarantees

- Determination of required pellet feed mixture
- Determination of required green pellet moisture level
- Determination of achievable grate factor (specific capacity) and pellet quality
- Determination of design data for the indurating machine, especially its firing and cooling zones

Optimized plant layout

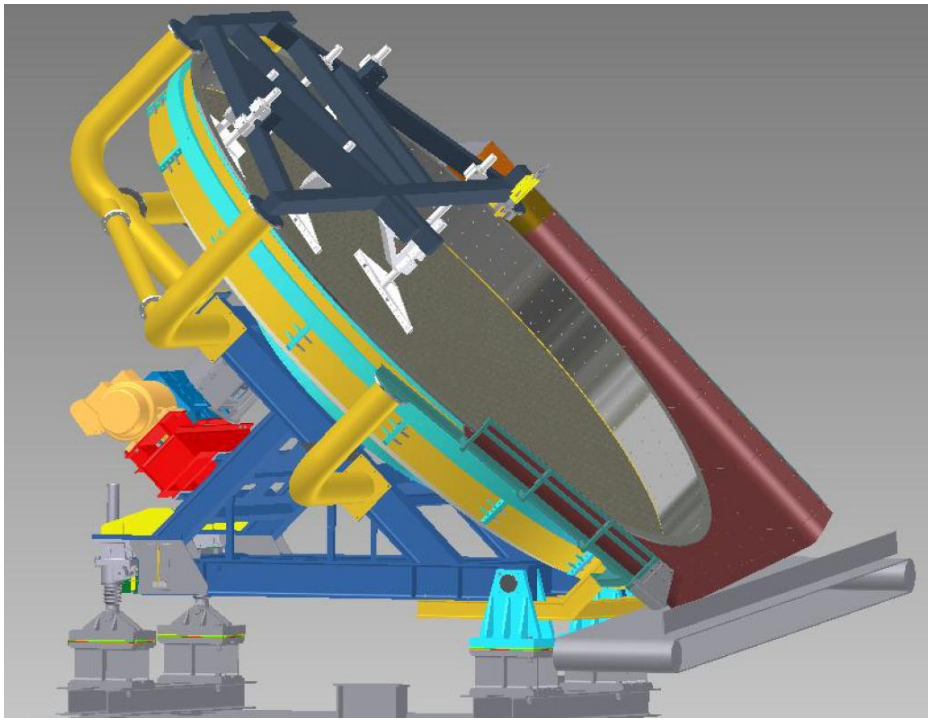


Significant years of development/optimization of plant layout has taken place

- Right angle plant arrangement of green pelletizing and induration
- Minimization of green pellet transfer points
- Single deck roller screens at each balling disc
- Long collecting conveyor with reciprocating head
- Single deck roller screen at machine feed area

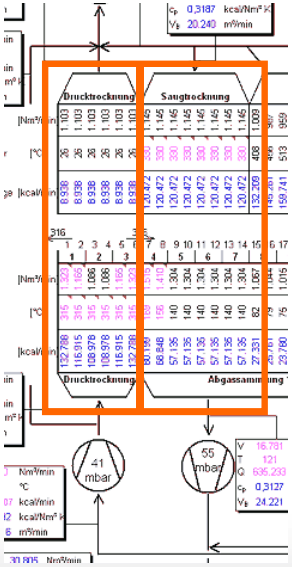
Pelletizing discs

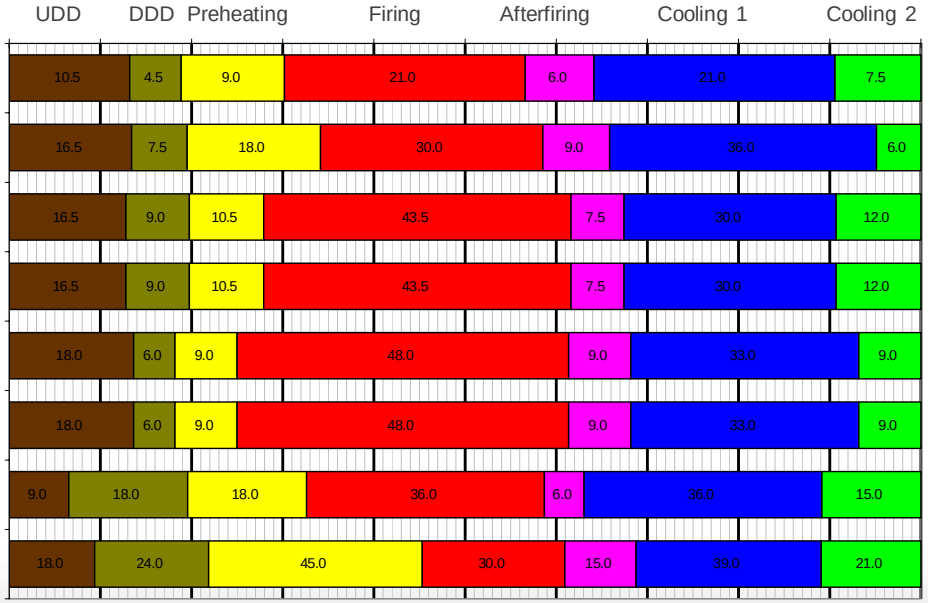
- Well proven, robust 7.5m disc
  - Standard design
  - One single drive
  - Mitigation of multiple drive synchronisation problems
- Designed for advanced green pelletizing control
  - Frequency controlled drive
  - Automated inclination control



Optimized zone distributions

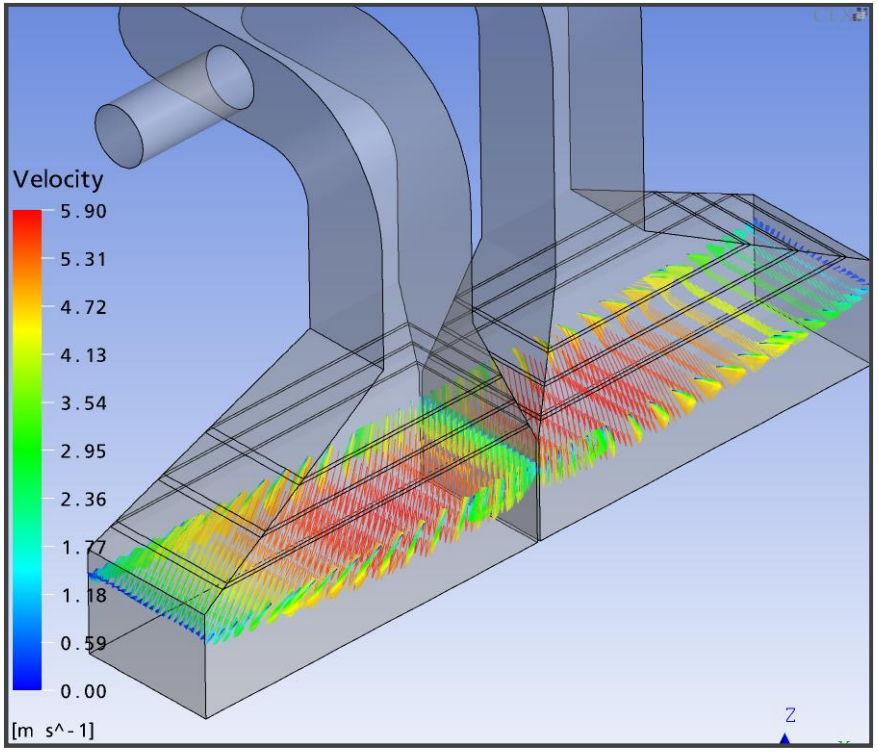
- Expansive experience of preheating/firing/cooling configurations for the processing of virtually any type of raw material (High LoI, High S)
  - Tailored temperature profiles can also be modified for variation in raw materials over plant lifetime
  - Equal heat treatment in all process zones
  - Discharge of homogenously cooled product pellets reduces risk of damaging downstream equipment





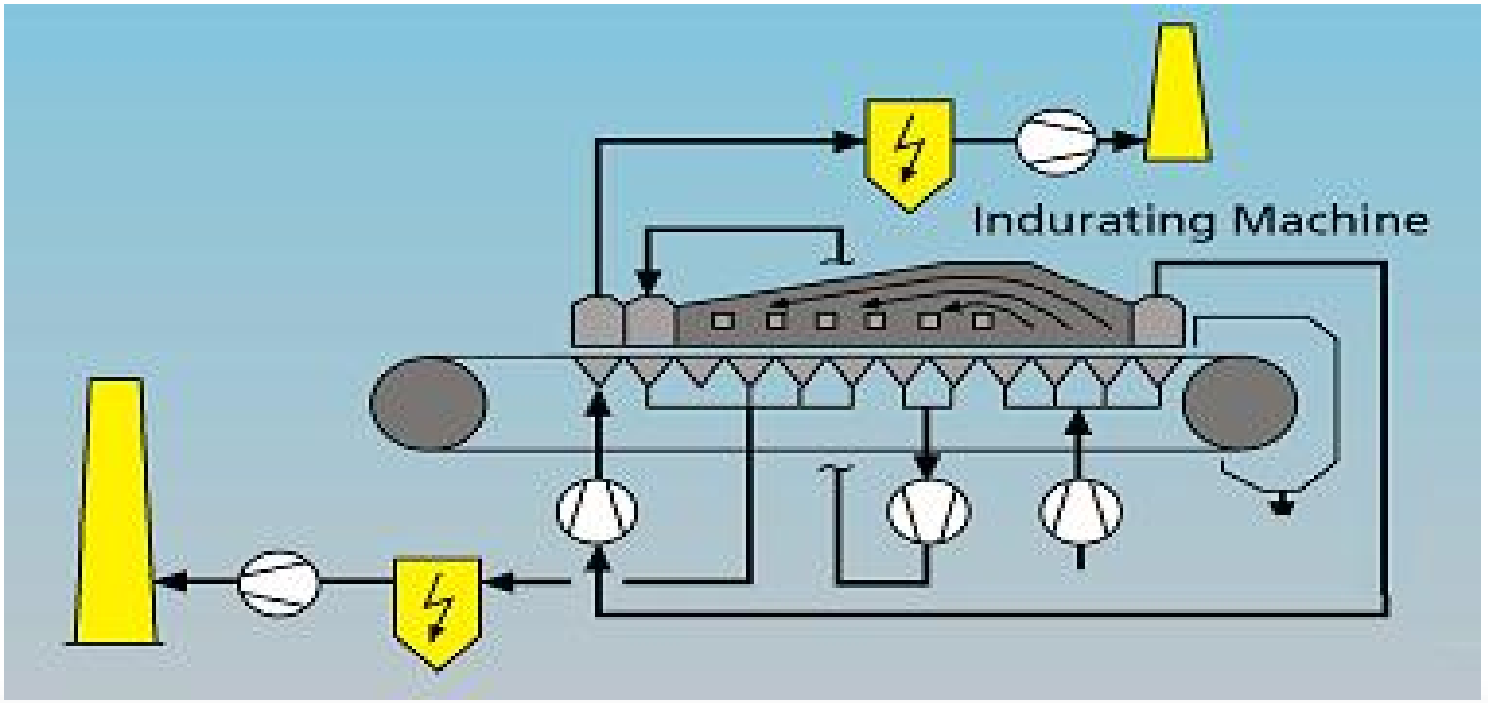
CFD optimization

- Development
  - Verification/optimization of critical duct systems for temperature distribution, gas velocities and pressure drop
- Application
  - Samarco 3 & 4, Brazil
  - LKAB MK 3, Sweden
- Benefits
  - Reduction of ductwork pressure drops and consequently reduction of electrical energy consumption
  - Improvement of plant operating conditions and efficiency of “gas flow-sensitive” equipment, such as ESP’s and process fans

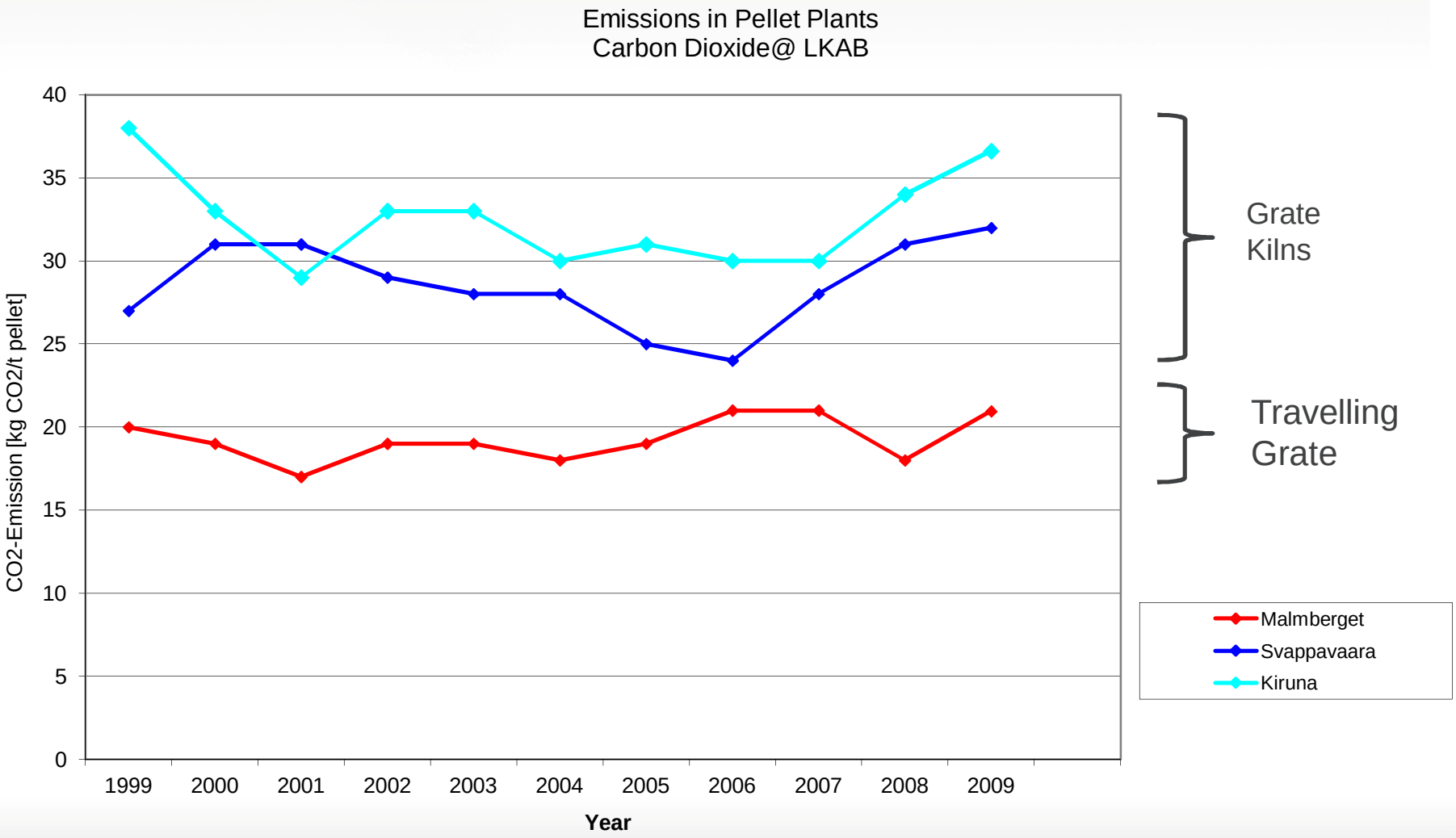


Energy efficiency

- Various recuperation principles tailored to specific customer requirements
  - Reduced overall energy consumption
  - Reduced offgas volumes to be cleaned and released to the atmosphere resulting in reduced environmental impact



Lower CO_2 emissions



Lower energy consumption

Plant Type	Grate Kiln	Grate Kiln	Grate-Kiln	Travelling Grate	Travelling Grate	Travelling Grate
Plant Location	Europe	Europe	South America	Europe	South America	South America
Year	2007	2007	2006	2007	2001	2007
Iron Ore Type	Magnetite	Magnetite	Hematite	Magnetite	Hematite	Hematite
Electrical Energy (Induration/Fans)	26.7 kWh/t	14.5 kWh/t	25.0 kWh/t	27.5 kWh/t	14.7 kWh/t	17.2 kWh/t
Thermal Energy (Gas/Oil+Carbon)	67,800 kcal/t	69,500 kcal/t	280,900 kcal/t	47,500 kcal/t	240,600 kcal/t	220,000 kcal/t
Total Energy Consumption	**105.5 kWh/t**	**95.3 kWh/t**	**350.6 kWh/t**	**82.7 kWh/t**	**294.5 kWh/t**	**273.0 kWh/t**

Total energy consumption of travelling grate is only 77-86% of competing systems

Higher reducibility

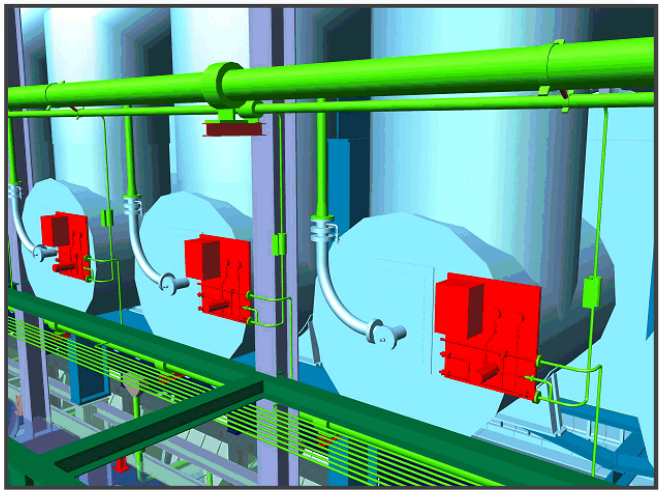
- No compaction of pellets required to maintain a high porosity for downstream reduction processes
- > 80 % of pellets processed by Midrex Direct Reduction plants worldwide are produced on travelling grates

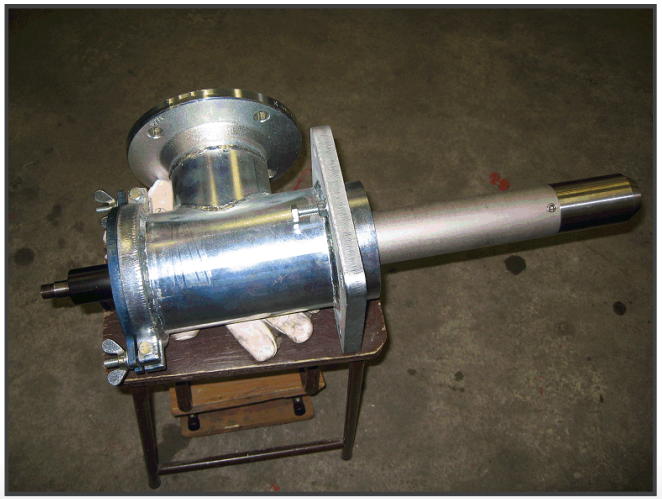
Photo: Hadeed – Module E (photo credit: Midrex)

Pellets remain undisturbed during the complete heat treatment process!

High pressure burners

- Development
  - Substitution of traditional low pressure oil atomizers by high pressure oil atomizers
- Application
  - LKAB, Sweden
  - Samarco 3 & 4, Brazil
    - Dual fuel burner to provide the option to swap over to natural gas in the future
- Benefits
  - Reduction of atomizing air volumes and consequently reduction of oil consumption
  - Better atomization of the oil, forming a controlled flame shape to avoid contact with the refractory, which causes erosion
  - More equal temperature distribution of the flame





Pallet cars

- Significant upside to pallet car/travelling grate concept
  - Pallet car maintenance carried out offline
  - No disturbance to production
  - Bed height flexibility
- Pallet car concept
  - Designed for purpose based on significant operating experience
  - Optimised for reduced side wall consumption
- Grate bars
  - Increased bed permeability (+45 %) - lower energy consumption
  - Modified alloy for higher temperature and wear resistance - lower grate bar consumption

Dry lintels

- Development
  - Elimination of longitudinal and transverse water cooled lintels of the indurating hood to support separation walls
  - Substitution with adapted refractory and steel structure design
- Application
  - MBR, Brazil
  - Tata, India
- Benefits
  - Elimination of the entire water cooling on the furnace (approx. 800m³/min)
  - Reduction of investment costs due to smaller cooling tower, piping and cooling water pumps
  - Reduced plant operating expenses

Better insulation

- Development
  - Improvement of the inside refractory and/or outside thermal insulation to achieve surface temperatures of furnace and ductwork below 80 ºC (instead of 120 ºC)
- Application
  - Samarco 3 & 4, Brazil
  - MBR, Brazil
- Benefits
  - Reduction of energy losses and consequently reduction of thermal energy consumption
  - Improvement of working conditions for operation personnel

Our reference list tells the whole story …

Operator	Location	Startup	Capacity (Mtpy)
S-GOK	Stary Oskol, Russia	2013	6.0
Samarco	Plant #4, Ponta de Ubu, Brazil	2013	9.25
Bhushan Power & Steel Ltd.	Rengali, India	2012	3.85
Tata Iron & Steel Co.	Jamshedpur, India	2010	6.0
Caofeidian	Caofeidian, China	2010	4.0
Brahmani River Pellets	Kalinga Nagar, Orissa	2010	4.0
MBR	Nova Lima, Brazil	2008	7.0
Samarco	Plant #3, Ponta de Ubu, Brazil	2008	7.25
Vale	Tubarão VIII, Vitória, Brazil	2008	7.0
Gol-e-Gohar Iron Ore Co.	Sirjan, Iran	2007	5.0
LKAB	MK3, Malmberget, Sweden	2006	2.5 – 4.0

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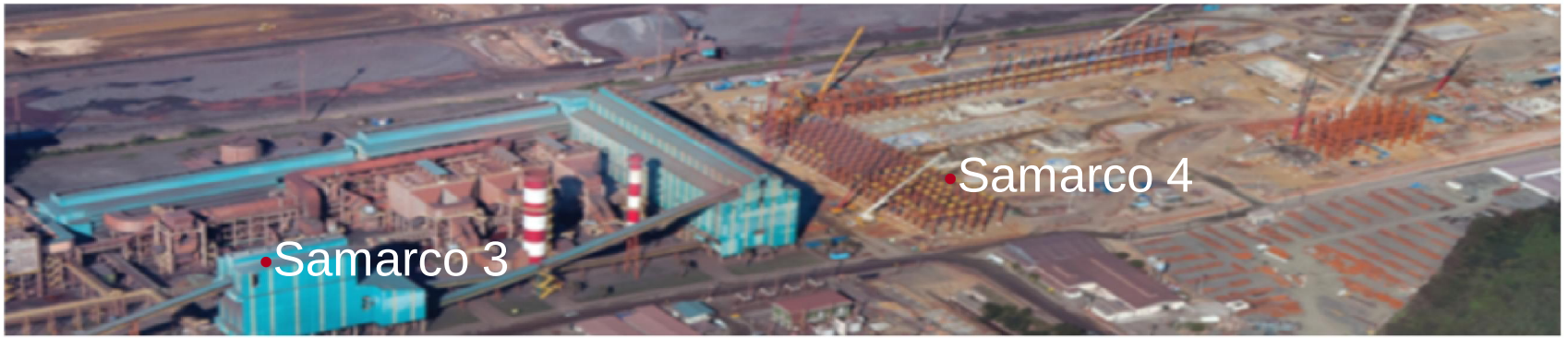
Project background

- After the successful implementation of the 7.25mtpa Samarco 3 project, Samarco commissioned Outotec to complete a study for the implementation of Samarco 4
- In 2010, Samarco approved the study and a LoA was issued, the contract was ultimately signed in March 2011
- Outotec commenced the engineering in a task force based in Belo Horizonte, with the implementation on a "fast track“ basis, namely 31 months until the first pellet is produced
- Scope of Outotec contract
  - Basic and detail engineering
  - Steel structural design, boiler, and electrical and mechanical equipment
  - Civil and construction, electro-mechanical assembly and plant commissioning

Samarco pelletizing plants

Contract details

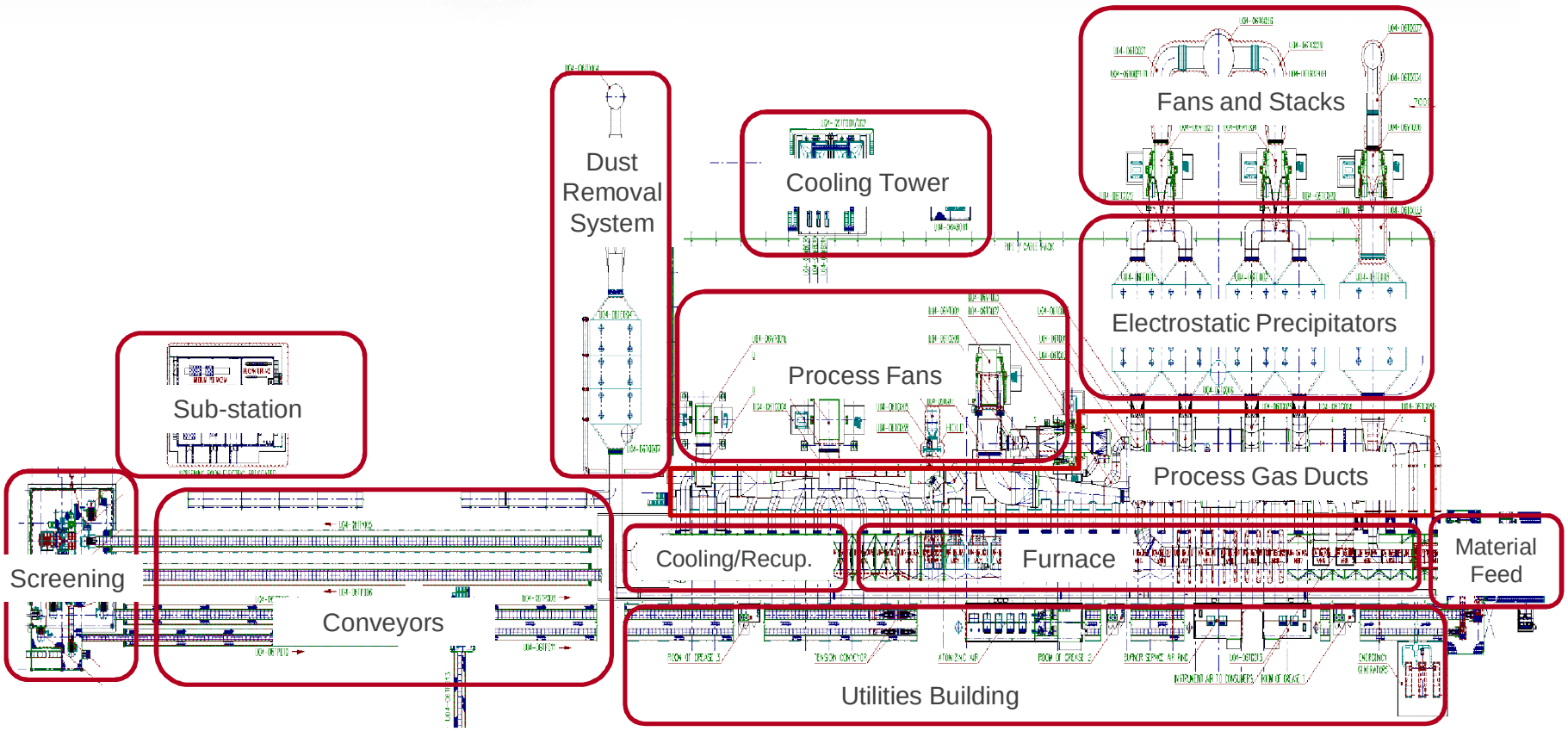
- Total Samarco investment: 700 million BRL (USD 350 million)
- Outotec contract value: ca. 200 million Euro (USD 266 million)
- Project implementation : 31 months
- Date of production of first pellet : 14. October 2013 (start-up)
- Plant capacity: 9.25 million tonnes of pellets per year
- Furnace size: 816m^2 - the World's largest pellet plant



Engineering – status

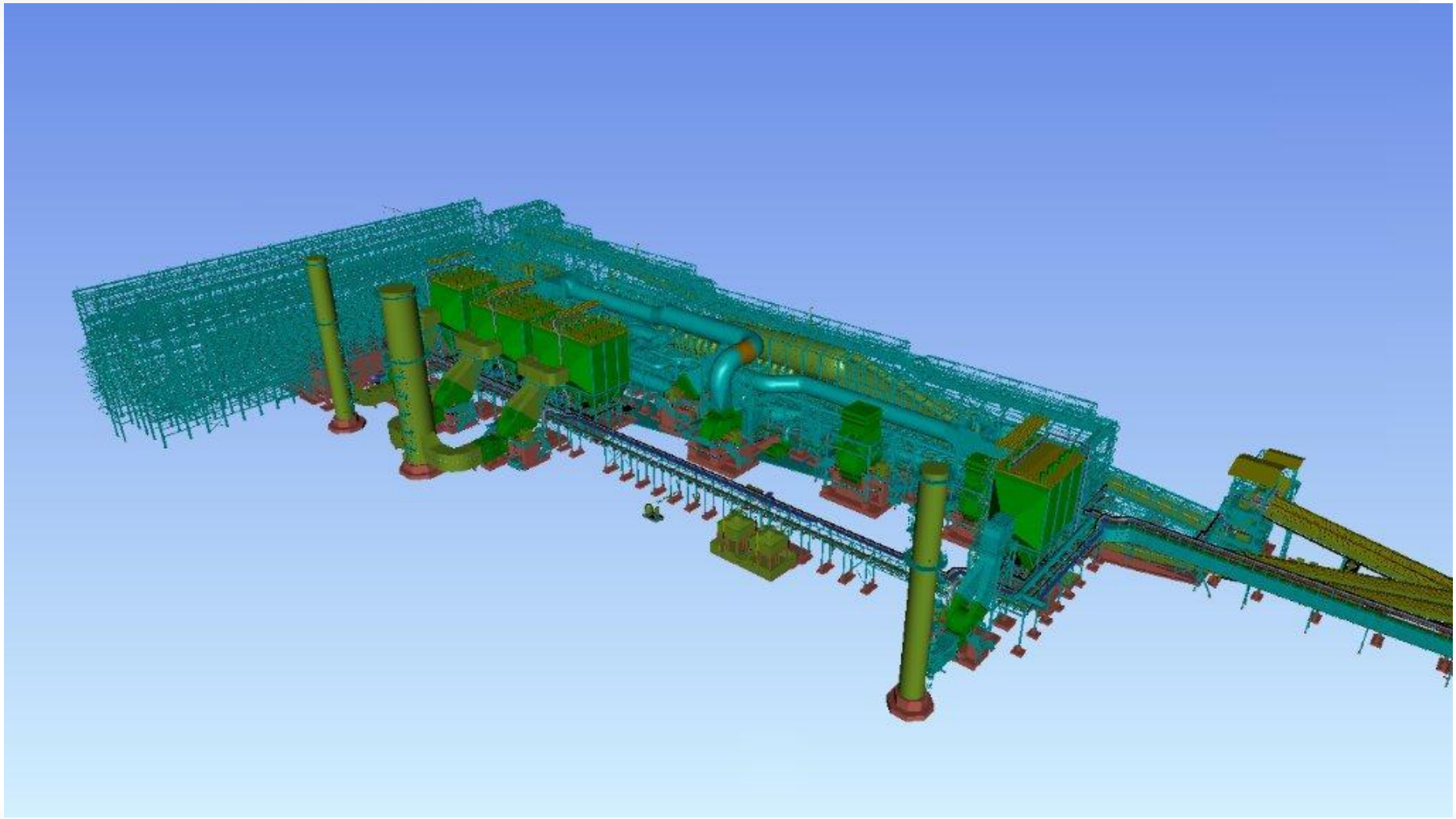
- Design engineering is 100% complete
- Engineering disciplines involved: process, mechanical, structural steel, civils, piping, electrical and instrumentation and control
- The entire engineering has been developed in 3-D (PDMS, Tekla, TQS, Inventor)
- In 16 months 5,500 drawings and documents have been produced by Outotec and its partners and subcontractors
- Internal and external document communication peaked in September 2012 at approximately 10,000 per month
- Project taskforce comprises
  - Local Outotec engineering team: 22 personnel
  - CRA and IHM team partners: 80 personnel (peak)

Engineering - Layout and Scope



Outotec

3D plant layout



Procurement status (January 2013)

- The current progress of procurement/supply is at 93%, including purchasing, manufacturing, inspection and on-site delivery
- Types of supplies: mechanical and electrical equipment, automation system, steel structure and piping
- 85% of the equipment has already been procured in 120 orders
  - 90% of suppliers are Brazilian
- 22,700 tonnes of material have already been delivered to the site

Construction status (January 2013)

Contractor: PARANASA

- Manhours estimate: 660,000
- Personnel: 400 (peak)
  - Direct: 316 + Indirect: 84
- Progress: 81% against forecasted 73%

- Construction data
  - 66,500 m^3 of excavating
  - 1,100 tonnes of steel
  - 15,000 m^2 of formwork
  - 11,900 m^3 of concrete

Electro-mech. assembly status (January 2013)

- Electro-mechanical assembly
  - Contractor: NIPLAN
  - Manhour estimate: 2,240,000
  - Personnel: 1,040 (peak)
    - Direct: 910 + Indirect: 130

- Refractory installation
  - Contractor: RIP
  - Manhour estimate: 342,000
  - Personnel: 260 (peak)
    - Direct: 220 + Indirect: 40

- Total estimated for construction: **3,242,000 Man-Hours**
- Current physical advancement: 11% of the forecasted 12%

Construction: Furnace View (January 2013)

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Summary

- The travelling grate is, and will remain, the dominating technology of choice for the iron ore pelletising industry
  - Plant capacity currently available from 1.0 to 9.25 Mtpy
  - Future capacity may well be higher than this!
- Process flexibility of the travelling grate
  - Magnetite, hematite and weathered ores
  - Profiles can be modified for variation in raw materials over plant lifetime
- Ongoing development of the technology continues with the most experienced pellet plant operators in the World
  - LKAB, Vale and Samarco
- Extensive Research and Development facilities in Frankfurt, Germany
  - In house R&D leading to upgraded designs
  - Specific process solution solving for global customer base

Sustainable use of Earth’s natural resources

Thank you for your attention!

Any questions?

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Outotec