TiZir

Prereduction and use of Hydrogen at TiZir

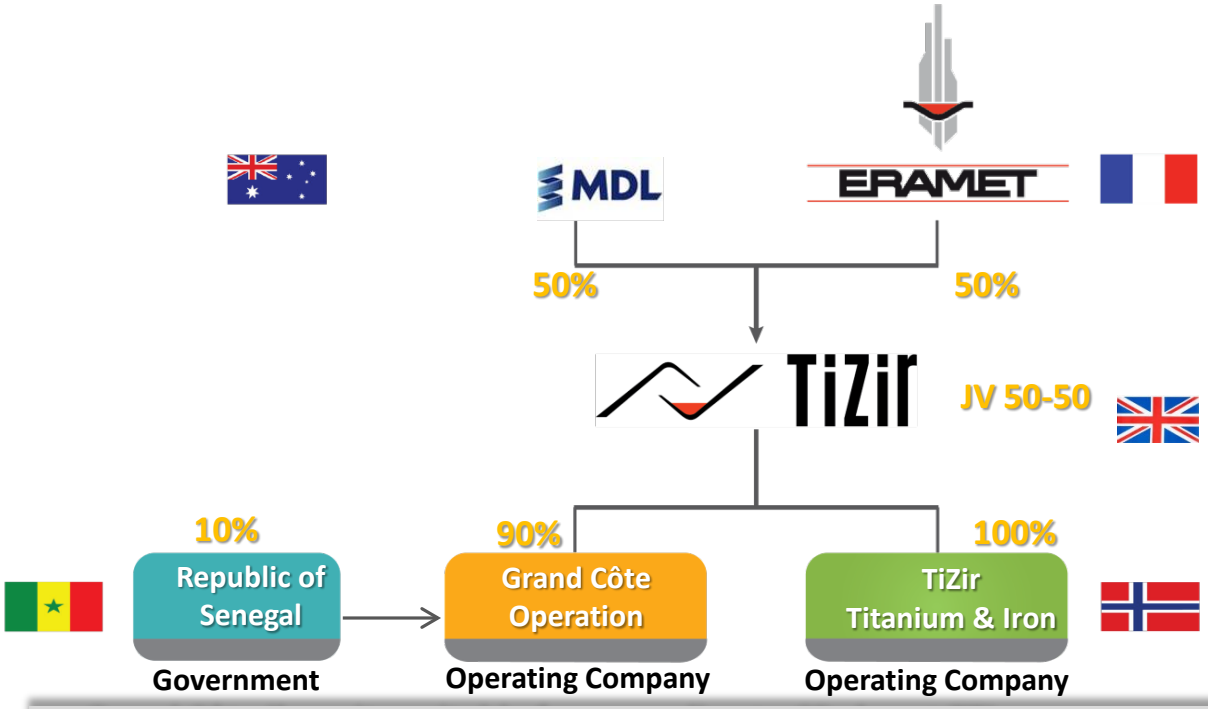
Harald Grande

TiZir plant in Tyssedal (TTI)

TiZir Limited, in a Snapshot

- Extensive Experience in HMS
- Concession of Grande Côte Operations (2007)
- DFS of Grande Côte Operations (2010)

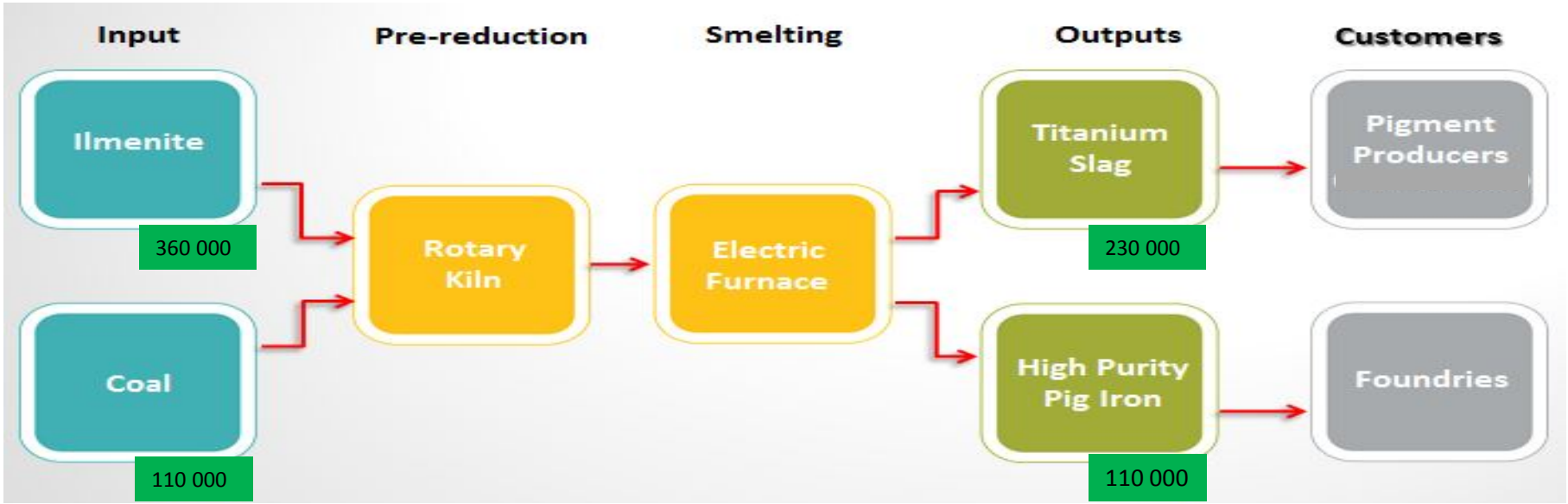
- Mining & Metallurgy Group (Ni, Mn, Alloys)
- Operate 2 Major Mines and 7 Smelters
- Tinfos Acquisition including TTI (2008)



- Grand Côte ilmenite suitable for upgrading to CP slag at TTI
- Security of ilmenite supply for TTI provides expansion opportunity
- Grande Côte Mine development commenced in July 2011
- Production started at the Mine in May 2014
- Total investments TiZir2011-2015 800 mill USD

TiZir's Two Operational Facilities

TiZir Titanium & Iron (TTI)



Grande Cote Operations (GCO)

100 x 4 km Mining Concession

Dredge WCP

7000 t/h

MSP

Wet & Dry Mills

Rail & Port

Ilmenite	575 kt/y
Zircon	85 kt/y
Rutile	6 kt/y
Leucoxene	10 kt/y

Hydrogen project at TTI, developing for the future

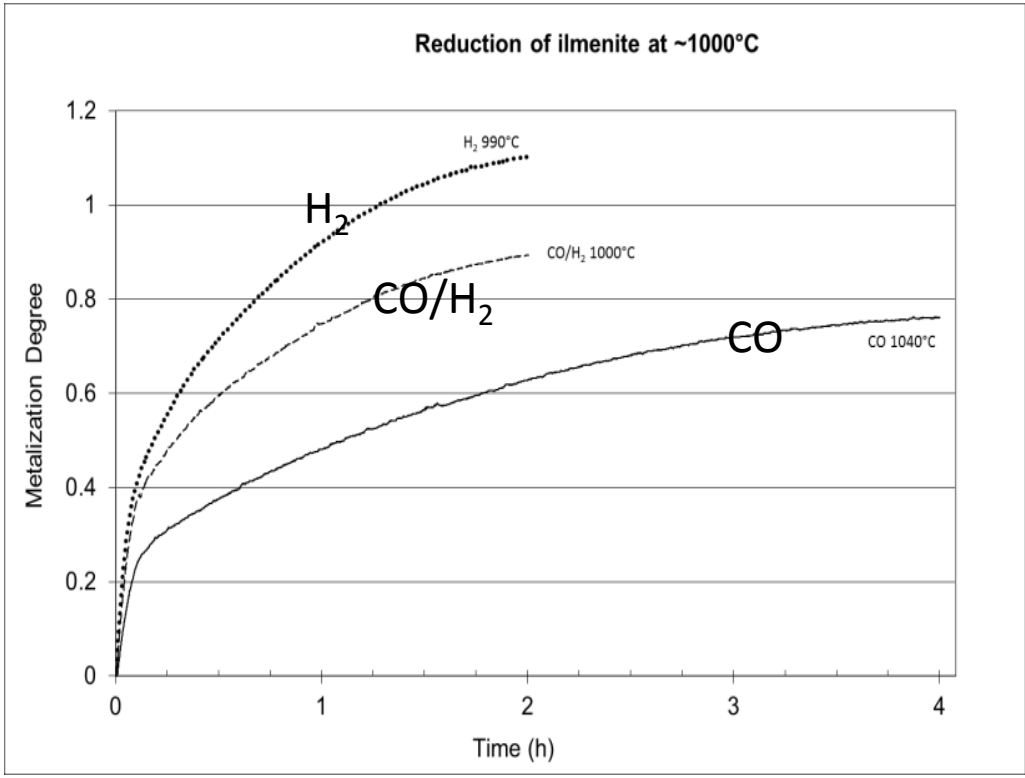
- Develop and expand
- A technology adapted to the future:
  - Power
  - Climate
  - Resources
- Limited footprint
- Core competence built over time internally and externally
- Strong process experience in modelling and control of multi stage processes.

Scientific community, important contribution

- Long history
- Close link to industry
- Strong Universities
- Strong research organizations
- Development of candidates for MSc and PhD
- Recruitment

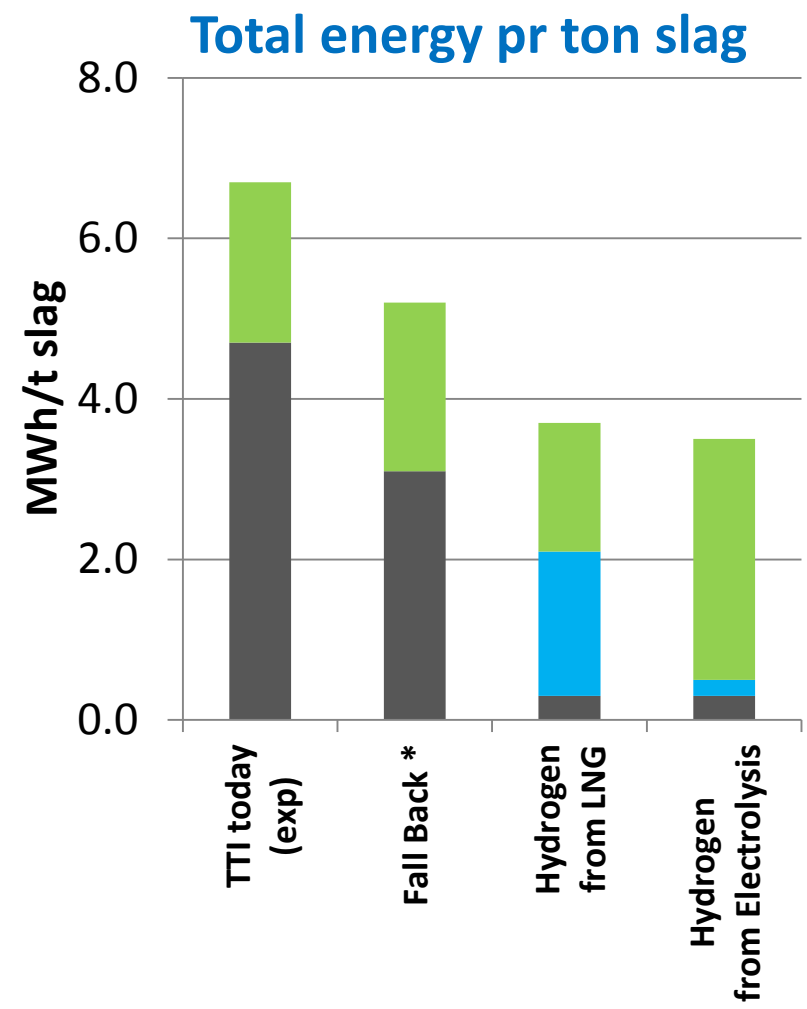
TTI apporach

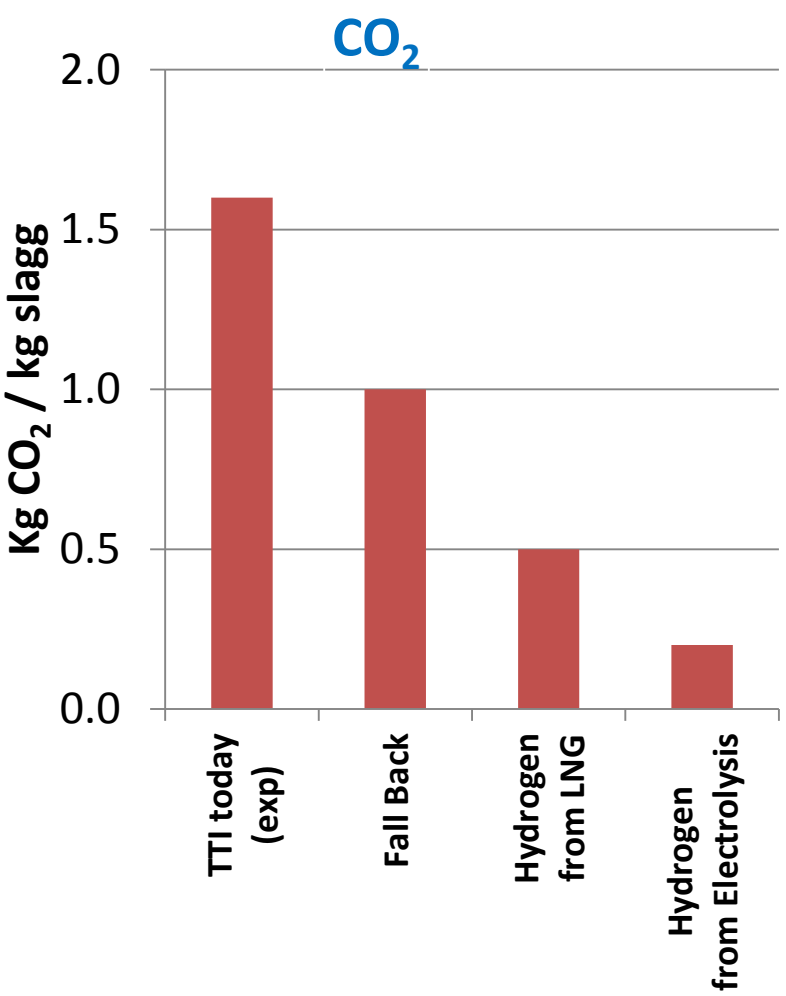
- **H_2 based pre-reduction**
  - Production increase
  - CO_2 reduction
  - Energy efficient
  - Development of core knowledge
  - Area efficient
  - Process responce
  - Operational security



Stephen C. Lobo, Experimental investigations and modelling of solid-state ilmenite reduction with hydrogen and carbon monoxide, Ph.D. thesis, NTNU, 2015.
GasFerroSil project

TTI apporach.





TTI Preparing to start a New Chapter

- **Main objectives of the 2015 project:**
  - New reactor design, worlds most advanced?

    Most Efficient Reactor
    - Capacity Increase + 15%
    - Process control, prepare for Hot Charging from Hydrogen reduction.
    - Working conditions, Environment, and Safety improvements
- **Reactor start up December 2015**
  - **<u>All objectives met within good margins</u>**
- **2016 Successful trials on continous lab-scale**

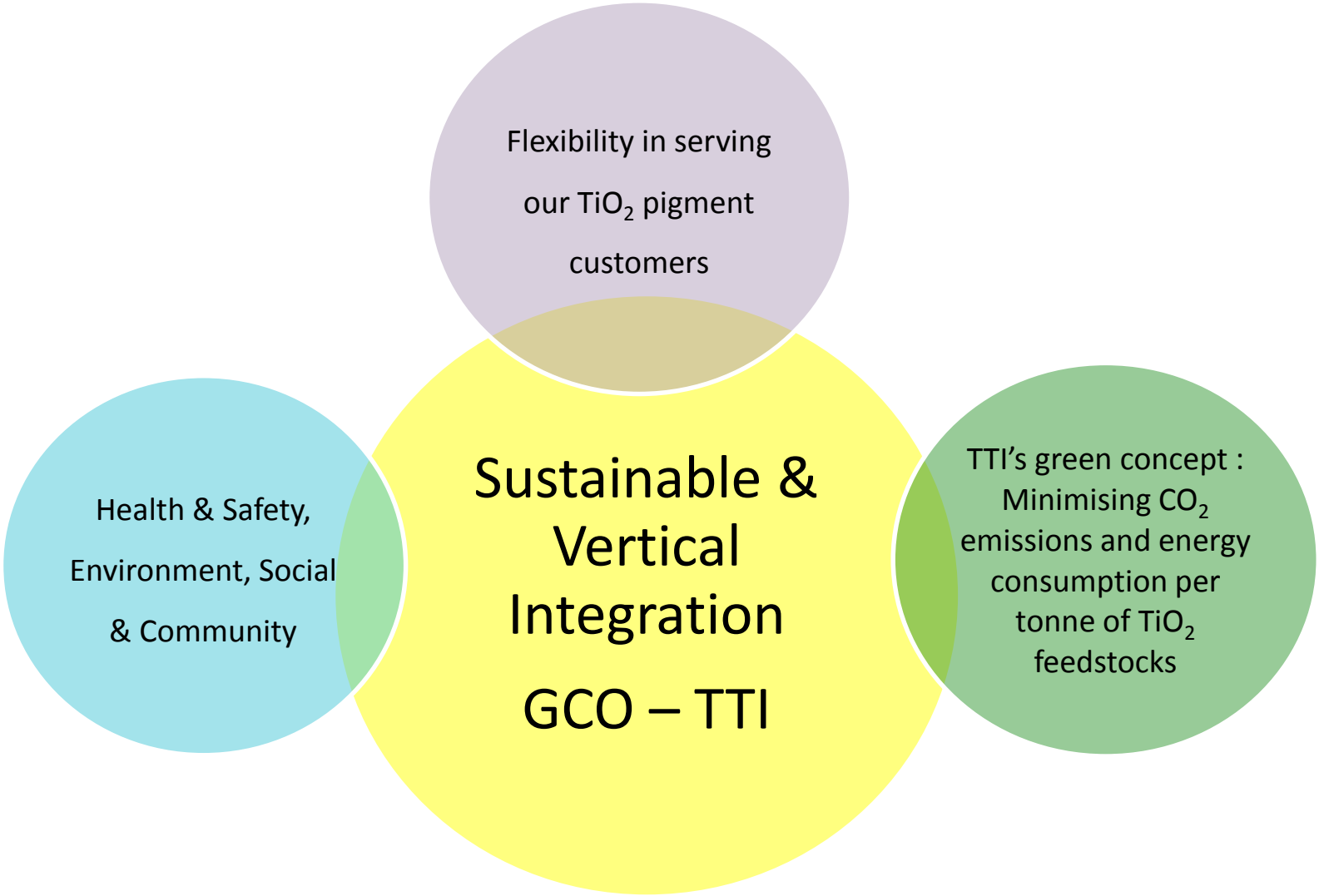
  H2-reduction tests close to being concluded.

Challenges :

Replacing a fully functioning production plant with another technology:

- Mostly finacial and regulatory:
  - Market(products and factor inputs (el))
  - Availabilty and level of govermental support
  - Availability and level of risk capital.
  - Emission costs.(CO2)

TiZir Heading for Operational Excellence



Thank you for your attention.

TiZir