

# GasFerroSil

Oslo, September 26, 2011

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## "Commercialization of Marginal Gas Fields"

Report from: The World Bank, September 1997

- **Main Categories for use of Natural Gas**
  - **Burn it** (flare, power plant, any other burner)
  - **Reinject it** (into the reservoir)
  - **Move it** (to the market by pipeline, LNG, etc.)
  - **Convert it** (chemically to other energy carriers)
  - **Use it** (for Reduction of iron ore, or for other metallurgical purposes)

# "Commercialization of Marginal Gas Fields"

## Report from: The World Bank, September 1997

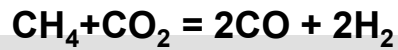
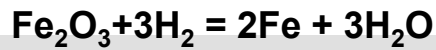
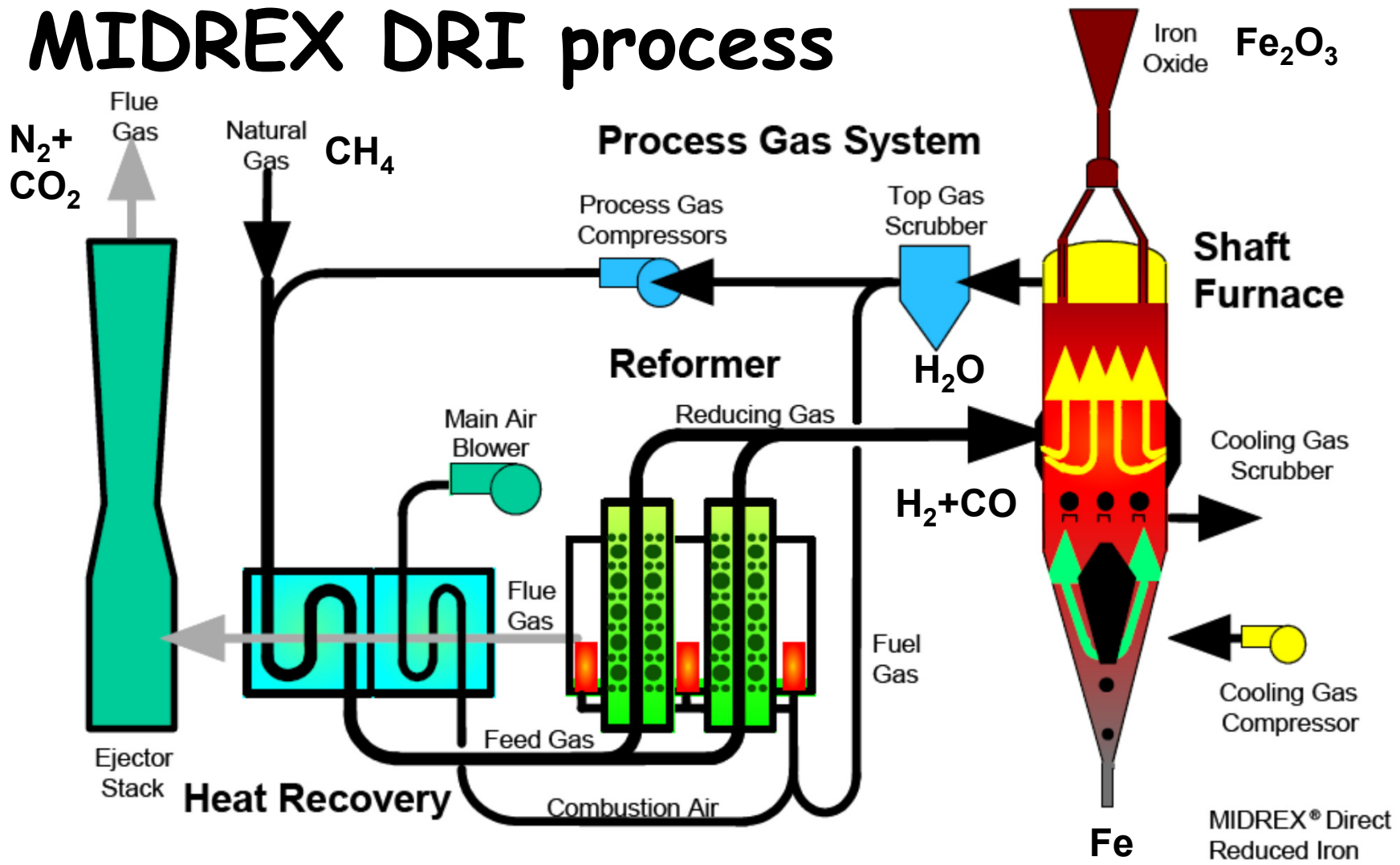
### Finansiere/Bygge fabrikk - drive i 25 år - hva kan betales for gassen?

Type Production	Prod. (TpD)	Gas (Gm <sup>3</sup> )	AGP* (NOK/m <sup>3</sup> )
Sponge iron (DRI, HBI)	3000	8.6	0.825
Carbon Black	120	1.68	0.725
Dimethyl Ether	4300	42.0	0.625
Methanol	2500	17.4	0.475
Ammonia	1800	14.0	0.375
Metanol Offshore	1500	11.2	0.325
GTO	2357	84.0	0.275
MTO	2357	84.0	0.175

\* Affordable Gas Price

Gm<sup>3</sup>=BCM

# MIDREX DRI process



# KMB - GASFERROSIL

## Use of Natural Gas in Ferroalloy and Si production and Ilmenite processing

The primary objective of GASFERROSIL is to investigate some typical optional uses of Natural Gas to produce ferroalloys and related products with lower energy consumption and/or CO<sub>2</sub> emission than today without compromising on the environmental goals laid out.

This overall objective will be reached by fulfilling the following sub-goals:

1. Develop the competence required to analyze and evaluate substitution of present use of coal and coke with natural gas.
2. Establish the basis for future development of processes for production of ferroalloys with natural gas.
3. Build interdisciplinary competence in thermodynamics and kinetics for production of ferroalloys and silicon that includes the possible usage of Natural Gas.
4. Educate Master students, PhDs, and Post doctoral fellows as well as scientists and other personnel in the partner organisations.

# KMB - GASFERROSIL WPs & Phases

## *Phase 1 (2011-2012)*

**WP0 Technical Feasibility** The work package will be managed by Senior Adviser Eli Ringdalen, SINTEF.

## *Phase 2 (2013-2016)*

**WP1 Pre-reduction of Ilmenite** Professor Leiv Kolbeinsen, NTNU in close cooperation with Stian Seim, EIT

**WP2 Manganese alloys** Professor Merete Tangstad, NTNU in close cooperation with Benjamin Ravary, Eramet

**WP3 Silicon & Ferrosilicon** Senior Adviser Bodil Monsen, SINTEF in close cooperation with Edin Myrhaug, Elkem

## *Phase 3 (2017-2018)*

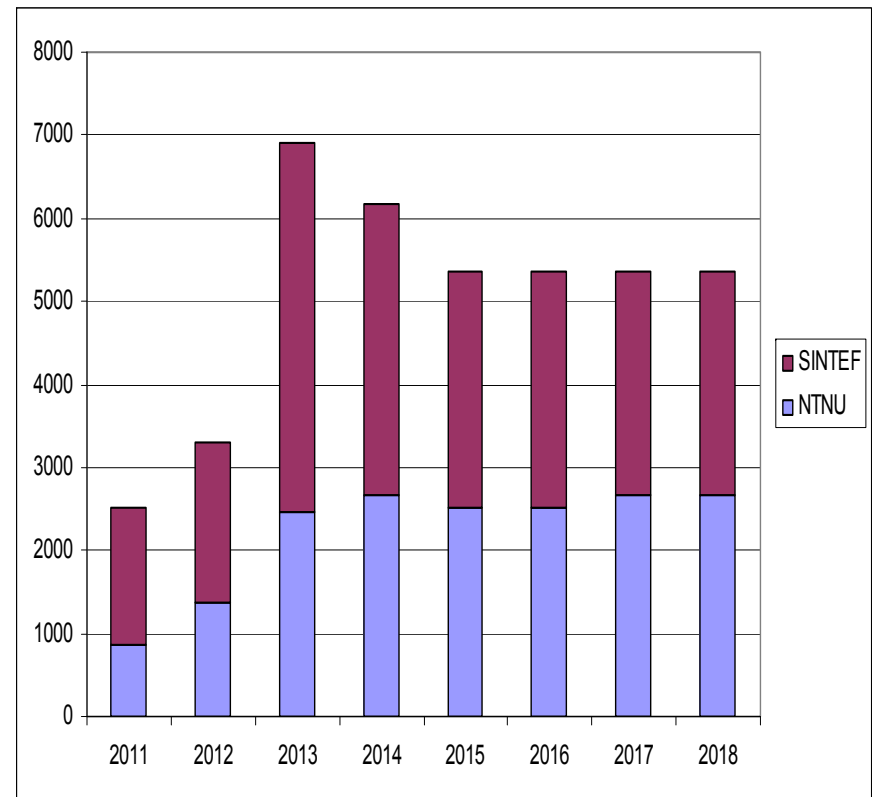
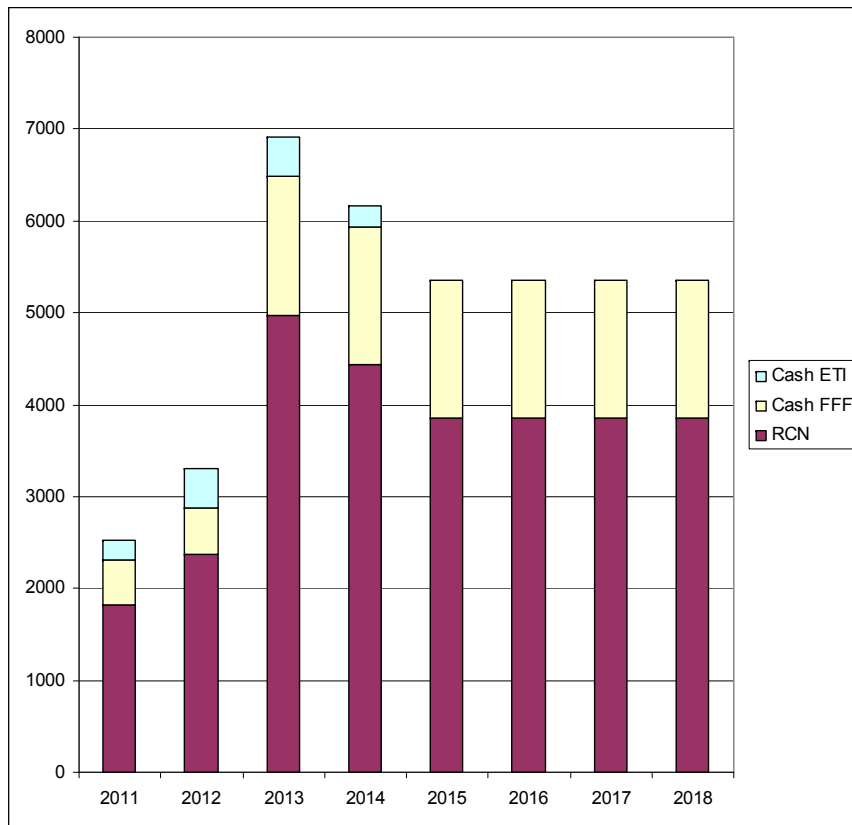
**WP4 Networking & Technology Transfer** Senior Adviser Eli Ringdalen, SINTEF.

**WP5 System & adjacent industries** Professor Leiv Kolbeinsen, NTNU

# Verifiable project objectives

- Within the first 12 months of the project, complete a feasibility study of possible usage of Natural Gas in the production of the three different product classes:
  - Titania-rich slag
  - Ferro Manganese
  - (Ferro) Silicon
- Between 12 and 18 months after start of the project:
  - Arrange seminars, meetings, workshops, etc. with industry representatives and invited key persons to decide the further direction
- Within 18 months from start of the project:
  - The relevant industries will evaluate which of the investigated uses of Natural Gas are viable
- Within 90 months from start of the project:
  - Develop competence and technologies necessary to reduce energy consumption per ton of product by 3 - 5 % for selected products of Norwegian Ferroalloy, Titania slag, and Silicon producers by July 2017
  - Educate 3 PhD and 2 Post Docs

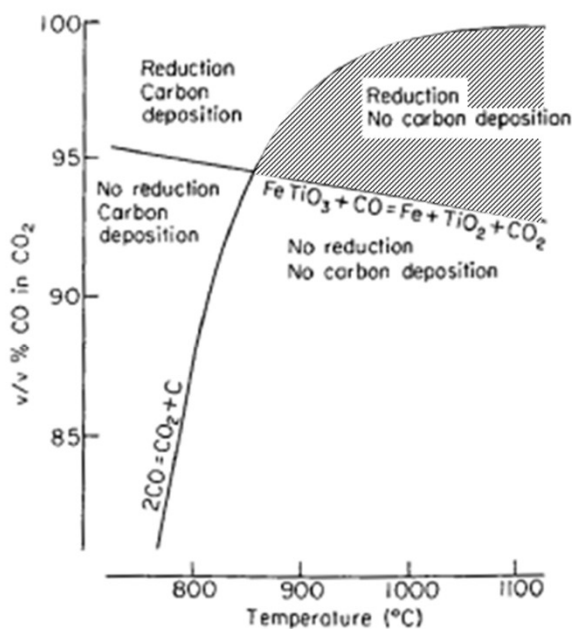
# Total Economy



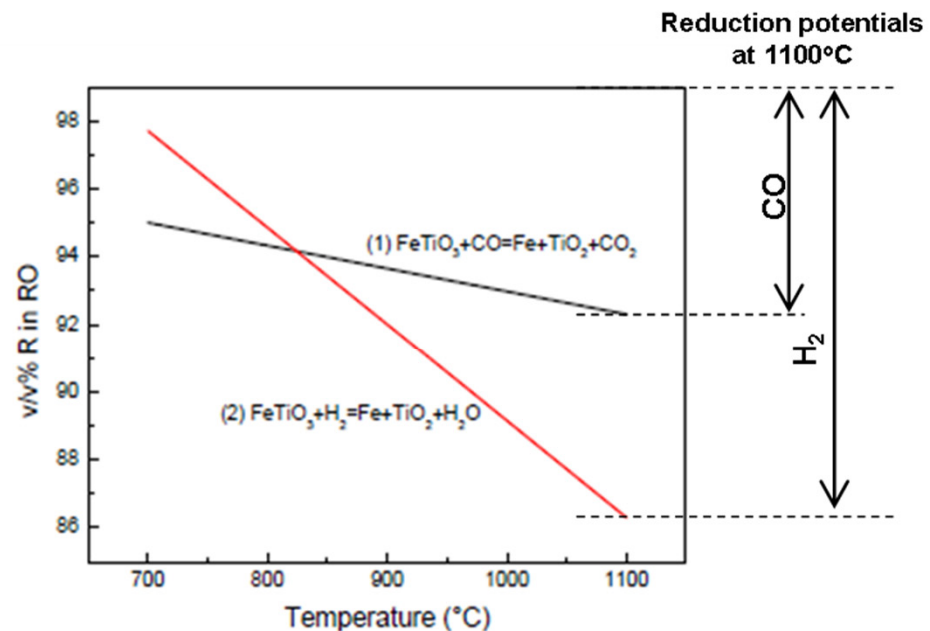
## WP 1 Reduction of Ilmenite (Metallization of Iron)

- Eramet Titanium & Iron (ETI) in Tyssedal produces  $\text{TiO}_2$ -rich slag and metallic iron from ilmenite ( $\text{FeTiO}_3$ ) in an electric furnace after pre-reduction with coal in a rotary kiln at about  $1100^\circ\text{C}$  so that about 60-70 % of the iron in the ilmenite is metallic before entering the smelting furnace.
- The process is called the *Tyssedal Process*, in which the pre-reduction is an integral part of the total process.
- Generally, the pre-reduction can also be done using gas mixtures of  $\text{CO}+\text{H}_2$ , e. g. synthesis gas made from Natural Gas.
- At *SINTEF Materials & Chemistry* and *NTNU Department of Materials Science and Engineering (DMSE)* suitable equipment is available for studying gas-based reduction processes, and ETI is engaged in such studies supporting project-/master-work in the academic year 2010/2011.

- A substantial part of the top gas from such a process will have to be recycled and mixed with the Natural Gas feed in an industrial application, and issues pertaining to this (e.g. limitations on gas mixtures due to different optional gas reforming processes) must be taken into consideration.
- A proposal on supporting up to 50% of a PhD is forwarded by ETI to Eramet Norway and was approved in a meeting Thursday October 15 2010. A PhD project starting as early as possible will probably be the most efficient way to provide and systemize the necessary experimental values and systemize those in the form of a process model.



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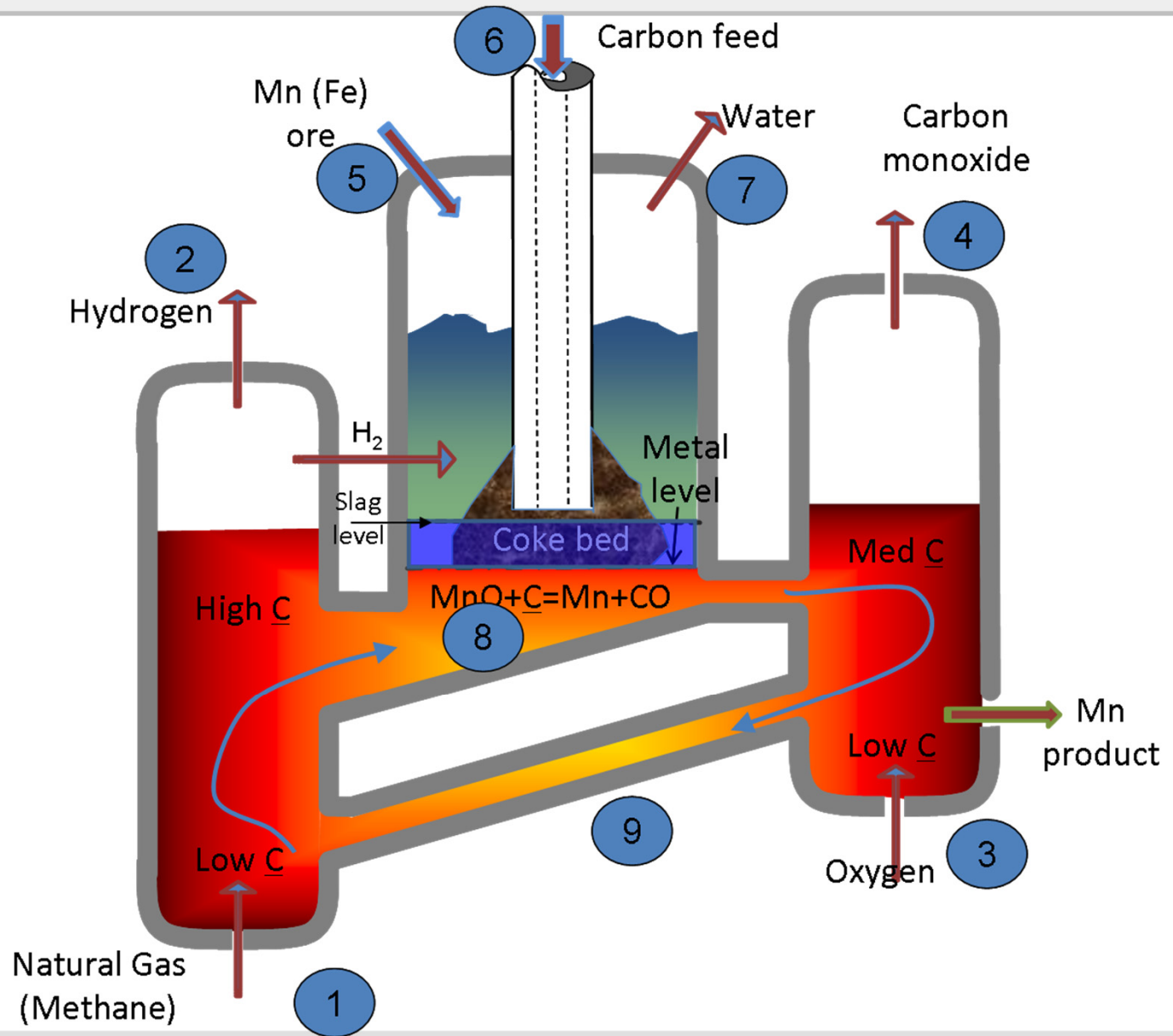


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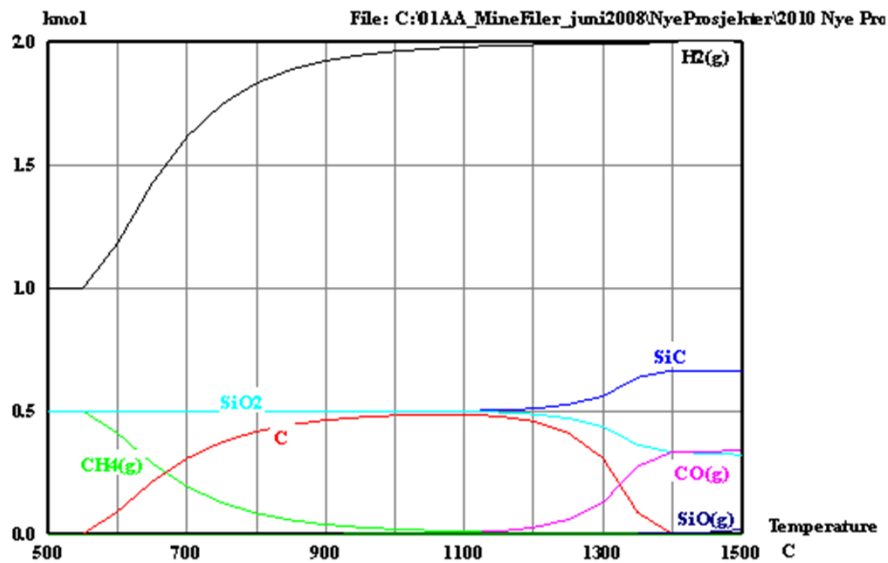
# WPO is to Plan and Validate WP's 1-3

- **WP1 As described earlier**
- **WP2 Manganese alloys**
  - **WP2 Research Tasks**
  - Investigation of reaction between slag oxides and dissolved carbon
  - Cracking of methane and dissolution of carbon
  - Oxidation of dissolved carbon
  - Energy balance between units/CFD modelling
  - **WP2 Outcome/results**
  - Description of system and discussion of challenges on theoretical basis
  - Experimental verification/negation of assumptions
  - "Process models"/description of mechanisms of central process steps
- **WP3 Silicon and Ferrosilicon**
  - **WP3 Research Tasks**
  - To be defined in WPO
  - **WP3 Outcome/results**
  - To be defined in WPO

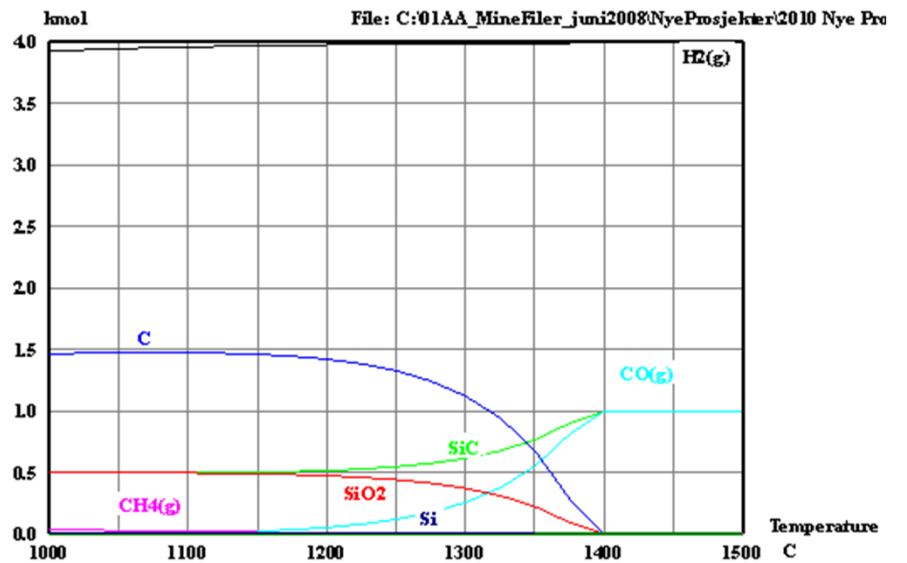
# WP2



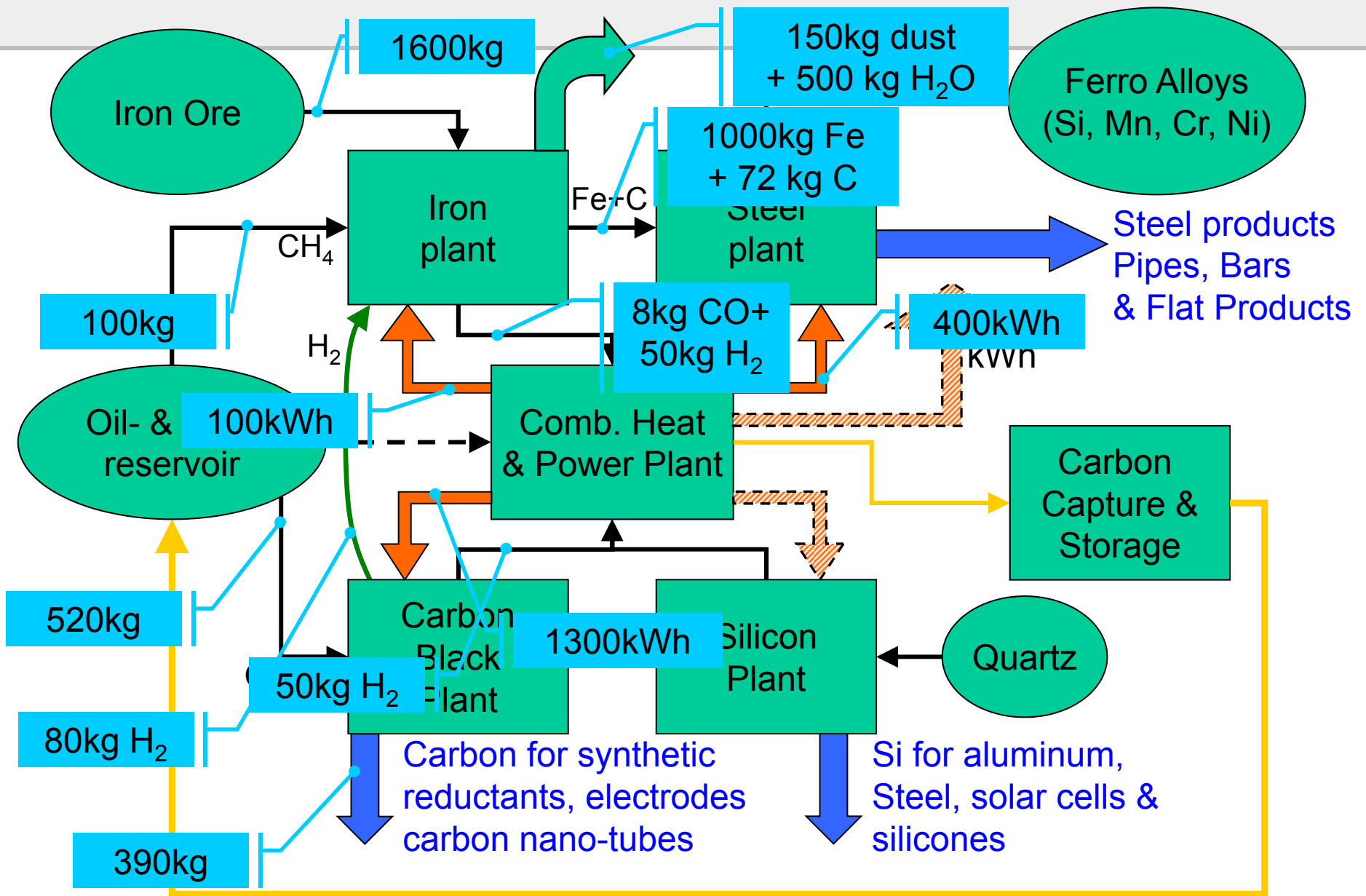
# WP3



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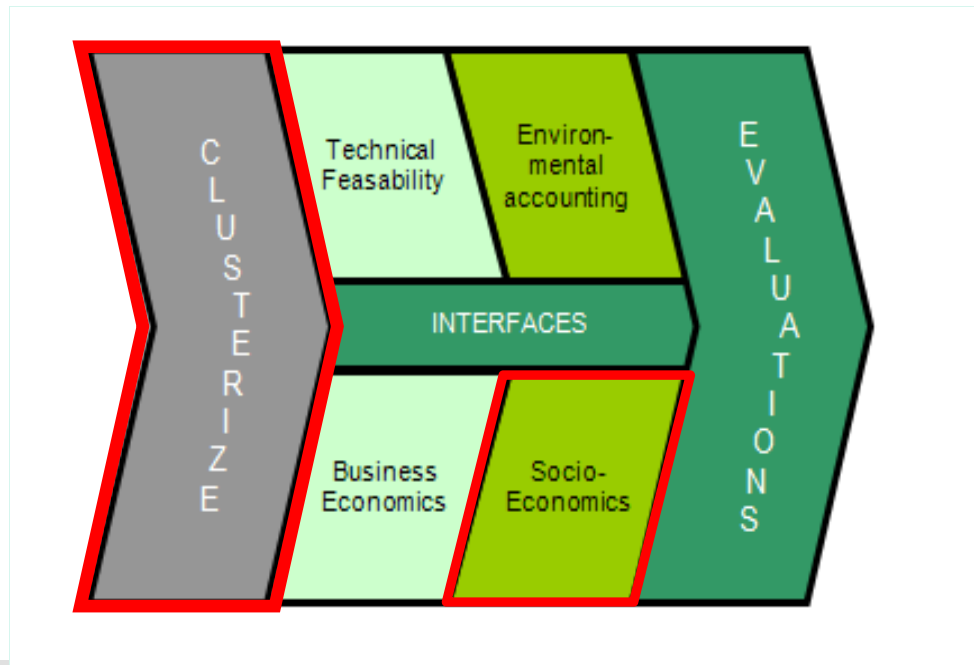
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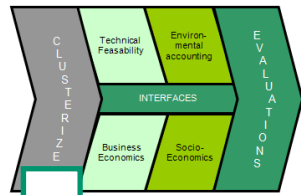
Closing the loop with return of CO<sub>2</sub> to reservoir for EOR?

# Modelloppbygging

- Beslutningstøttesystem for bedrifter som vurderer å gå inn i en industriklynge
- Strategisk modellsystem som ikke benyttes så ofte - derfor må modellen benyttes sammen med "eksperter"
- De ulike arbeidspakken har ulikt perspektiv og bruk

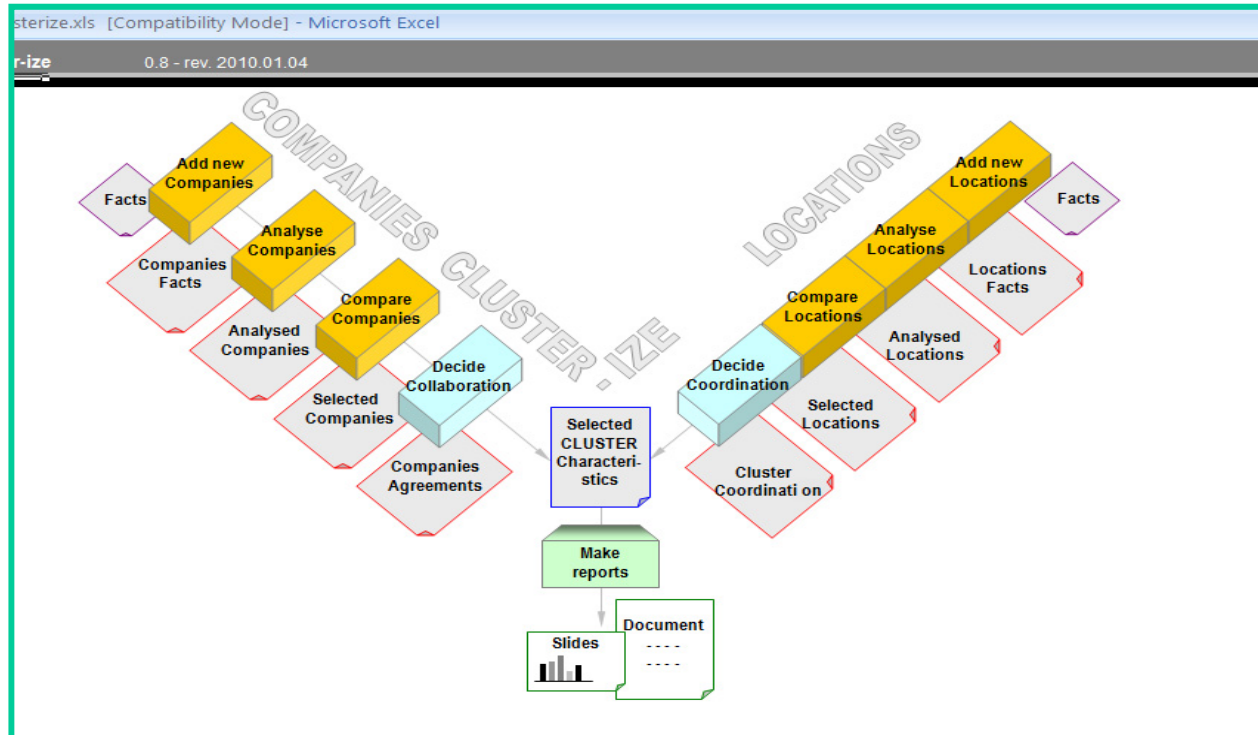


# GassMat overall methodology



Click on the icons to explore information about the topics and their tools  
 Click on the interface to see the information flow and other interactions between the tools

# Clusterize



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**Alle Sover !**