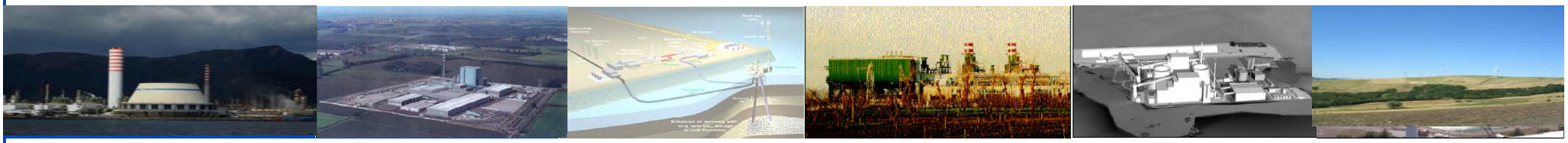
# EVALUATION OF POSSIBLE INSTALLATION OF $CO_2$ CAPTURE FACILITIES IN AN EXISTING IGCC PLANT



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# BACKGROUND OF THE STUDY

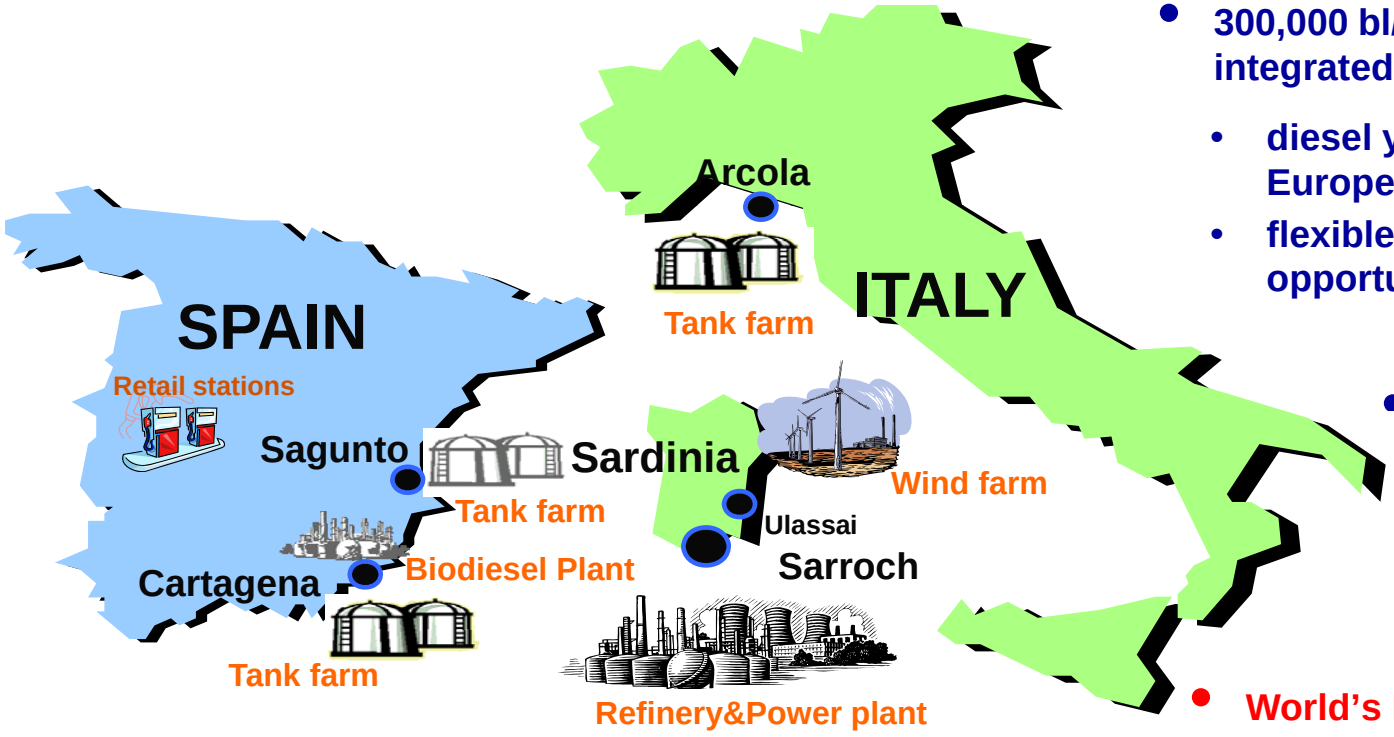
- **Global reduction in emission of 30% in developed world by 2020 is expected to be required**
- **EU directive on greenhouse gas emissions allowance trading system (post Kyoto) will consider the opportunities offered by CCS**
- **Energy efficiency and renewables help but do not solve the problem**
- **Significant $CO_2$ reductions cannot be achieved if we do not capture $CO_2$ from industrial installations (re. to EU Directive-draft-23/01/08)**
- **Pre-combustion CCS is a sound technical choice to combat climate change**

# TOPICS

- **What is SARAS?**
- **Description of the existing IGCC plant**
- **$CO_2$ capture from an existing IGCC plant**
- **$CO_2$ capture options**
  - **"Minimum" capture**
  - **"Maximum" capture**
- **Conclusions**

# SARAS IN A SNAPSHOT

**PURE PLAY REFINER WITH STABILIZATION OF RETURNS FROM POWER GENERATION**

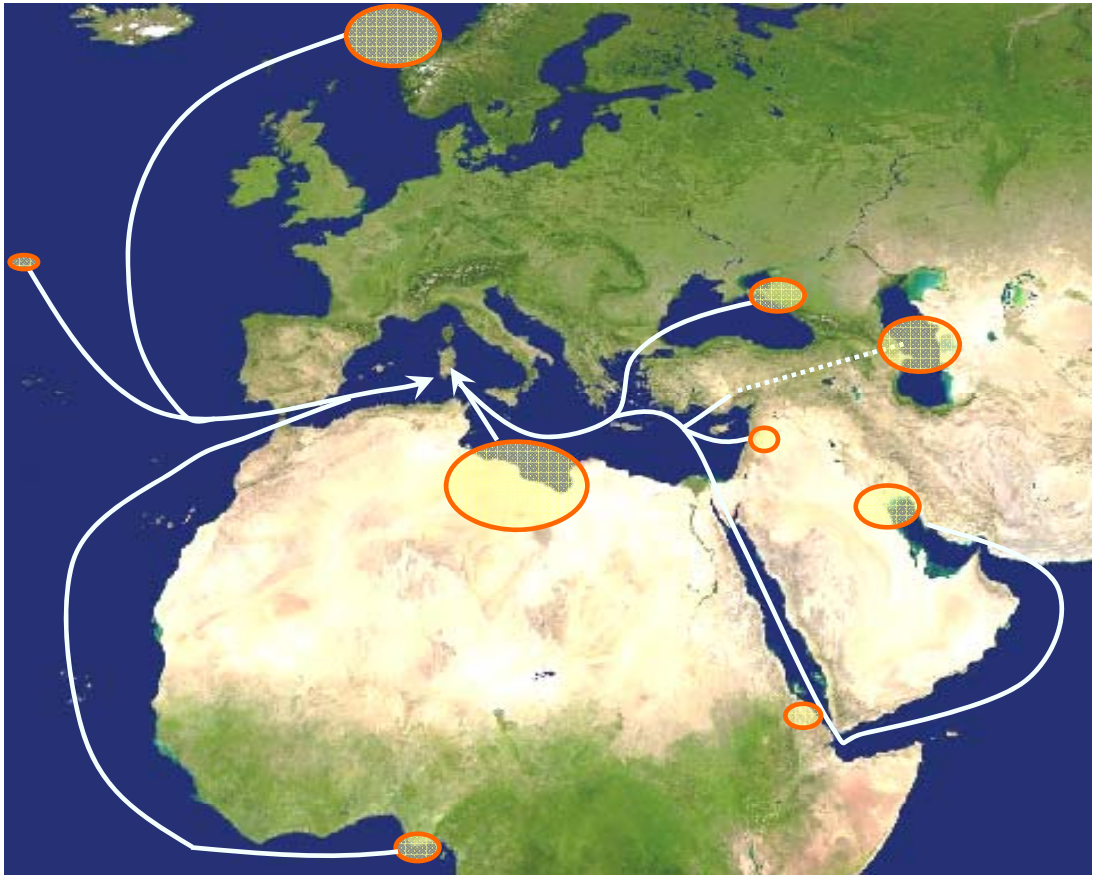



- 300,000 bl/day high complexity refinery integrated with petrochemical & power
  - diesel yield above 50%, the highest amongst European listed refiners
  - flexible operations to exploit market opportunities
- Marketing activities based in the high diesel demand regions of Italy and Spain
- World's largest liquid fuel gasification plant, converting heavy bottoms into clean gas, fed into a 575 MW CCGT
  - fuel oil yield close to zero
- Investing also in renewable energy
  - 72 MW wind farm located in Sardinia

# COMPETITIVE POSITIONING

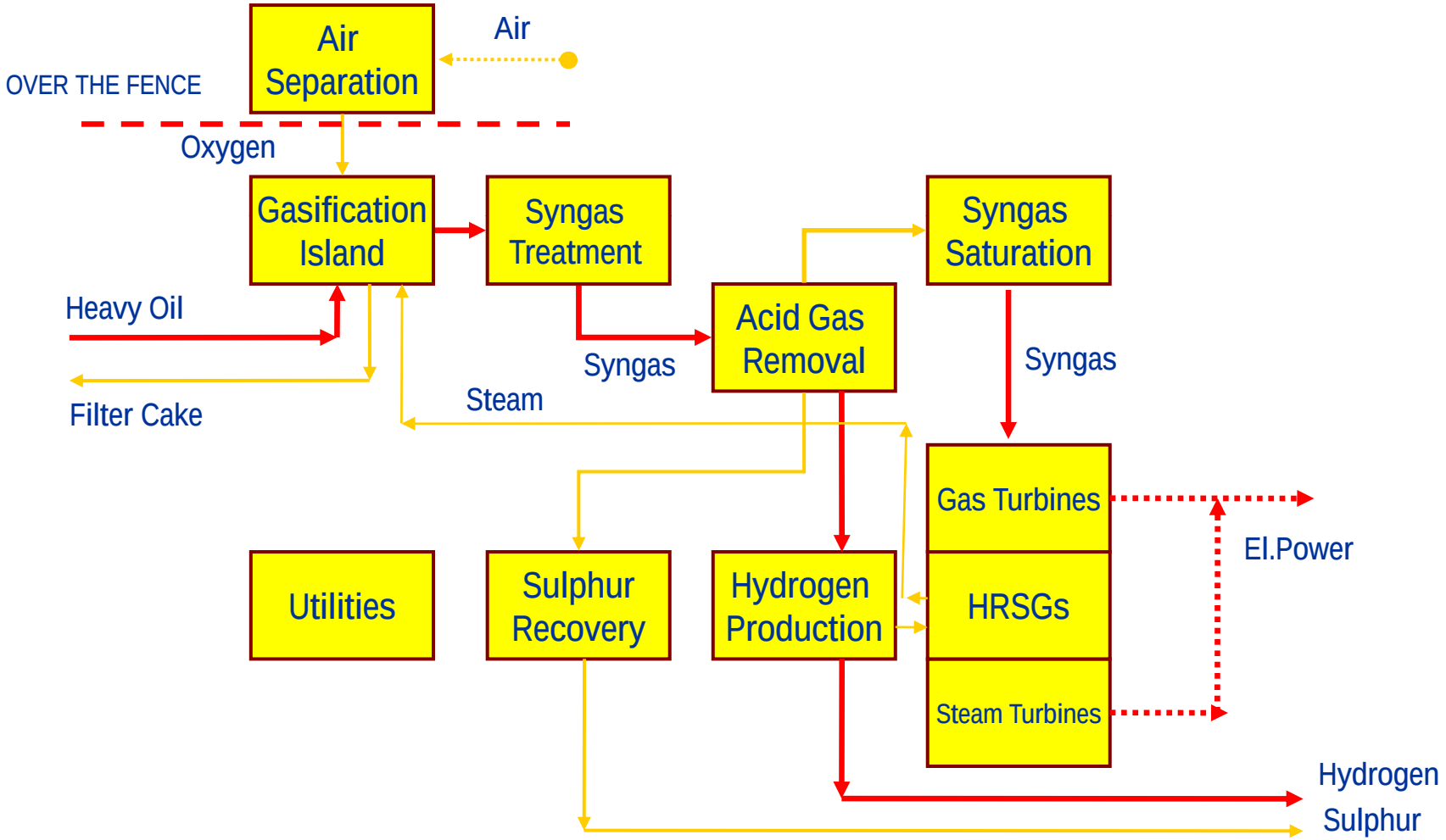
## FLEXIBILITY AS A FURTHER SOURCE OF COMPETITIVE ADVANTAGE

- **Flexible refinery configuration allows to run simultaneously up to 5 different crudes**
- **Technological enhancements to our processing units and improved logistic infrastructure offer the possibility to run "unconventional" crudes (higher value)**
- **Strategic location, in the center of the Mediterranean Sea, enhances flexibility of supply**



**Saras' 2007 main crude sources**

# IGCC – Existing Plant Block Flow Diagram



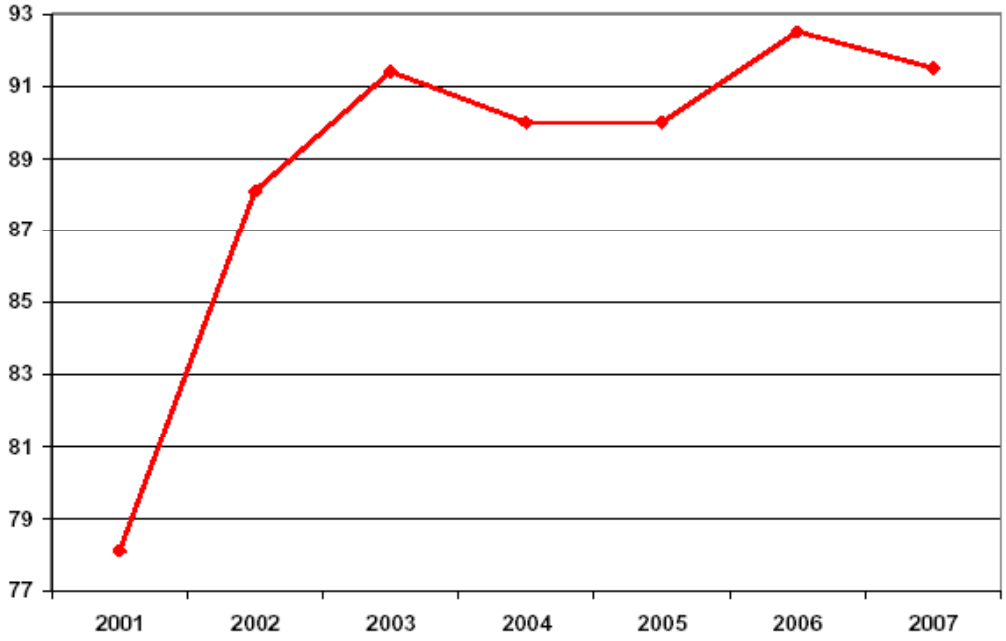
# IGCC CONFIGURATION

- **Gasification Unit (3 x 33 % trains):**
  - **152 t/h heavy oil**
  - **“low pressure direct quench” GE Energy (ex Texaco)**
- **Syngas Treatment (2 x 50 % trains):**
  - **Heat recovery by steam generation and water preheating**
  - **COS hydrolysis**
- **Acid Gas Removal (2 x 50 %):**
  - **UOP (Selexol™)**
- **Hydrogen Purification (60000 $Nm^3/h$):**
  - **Membranes/PSA**
- **Combined Cycle (3 x 33 % single shaft trains):**
  - **GT GE 9E (135 MWe) – ST GE (60 MWe)**
  - **185 t/h MP/LP steam export to refinery**
- **SRU & Tail Gas Treatment**

# IGCC AVAILABILITY

**Plant Start-up in 2000. IGCC availability has increased due to the technical improvements and to the O&M management optimisation.**

| Year | Availability |
|---|---|
| 2001 | 78.1% |
| 2002 | 88.1% |
| 2003 | 91.4% |
| 2004 | 90.0% |
| 2005 | 90.0% |
| 2006 | 92.5% |
| 2007 | 91.5% |




NOTE: Plant availability includes also the scheduled shutdown

# IGCC PERFORMANCE

| | | |
|---|---|---|
| Gasification Feed Flowrate | t/h | 152 |
| Syngas Thermal Power (gasification scrubber outlet) | MWth | 1474.0 |
| Hydrogen Production | $Nm^3/h$ | 60,000 |
| Hydrogen Production | MWth | 180 |
| LP Steam Export to refinery | t/h | 80 |
| MP Steam Export to refinery | t/h | 100 |
| Steam Export (overall) | MWth | 142 |
| Power Output from 1 GT | MWe | 135 |
| Power Output from 1 ST | MWe | 60 |
| Gross Power Output | MWe | 585 |

# $CO_2$ Capture from an Existing IGCC Plant

- **ALTERNATIVE 1: Minimum capture of $CO_2$ contained in syngas ex gasification**
- **ALTERNATIVE 2: Maximum capture with addition of two CO shift stages (approx. 85 %)**

**Typical Syngas Composition (current operation)**

| | Ex Gasification<br>% vol. |
|---|---|
| $H_2O$ | 55 % |
| $H_2$ | 20 % |
| CO | 20 % |
| $CO_2$ | 5% |

## ALTERNATIVE 1 - $CO_2$ Minimum Capture Case

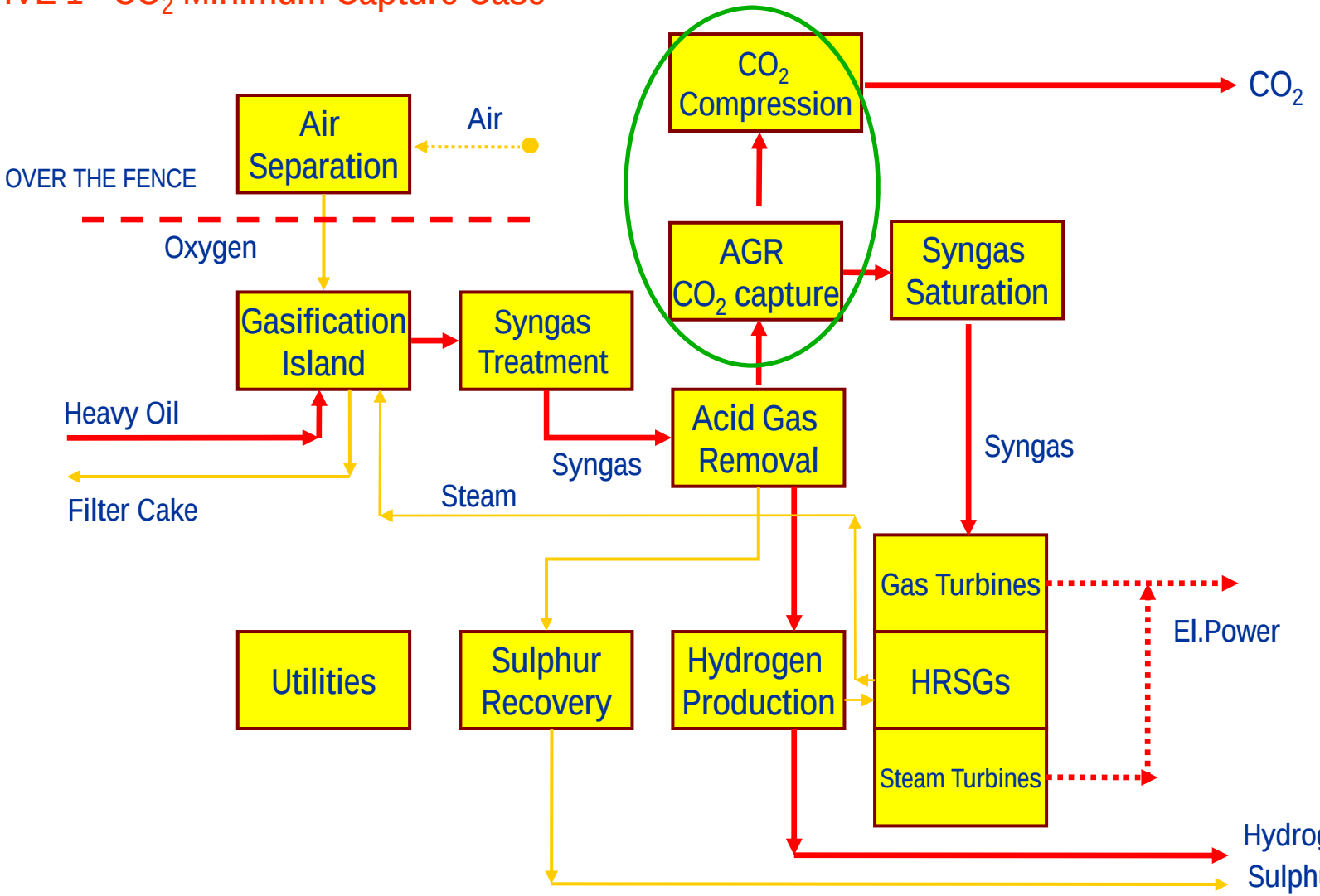
**REQUIRED INSTALLATION :**

- AGR modification (New $CO_2$ absorber and new flash gas compressors)
- New $CO_2$ drying and compression unit
- Modifications to gas turbine burners
- Implementation of SCR in HRSGs ($NO_x$ control)

**CHECK REQUIRED:**

- Sulphur Recovery Unit
- Nitrogen/Steam injection alternative to SCR

# ALTERNATIVE 1 - $CO_2$ Minimum Capture Case



# ALTERNATIVE 2 - $CO_2$ Maximum Capture Case

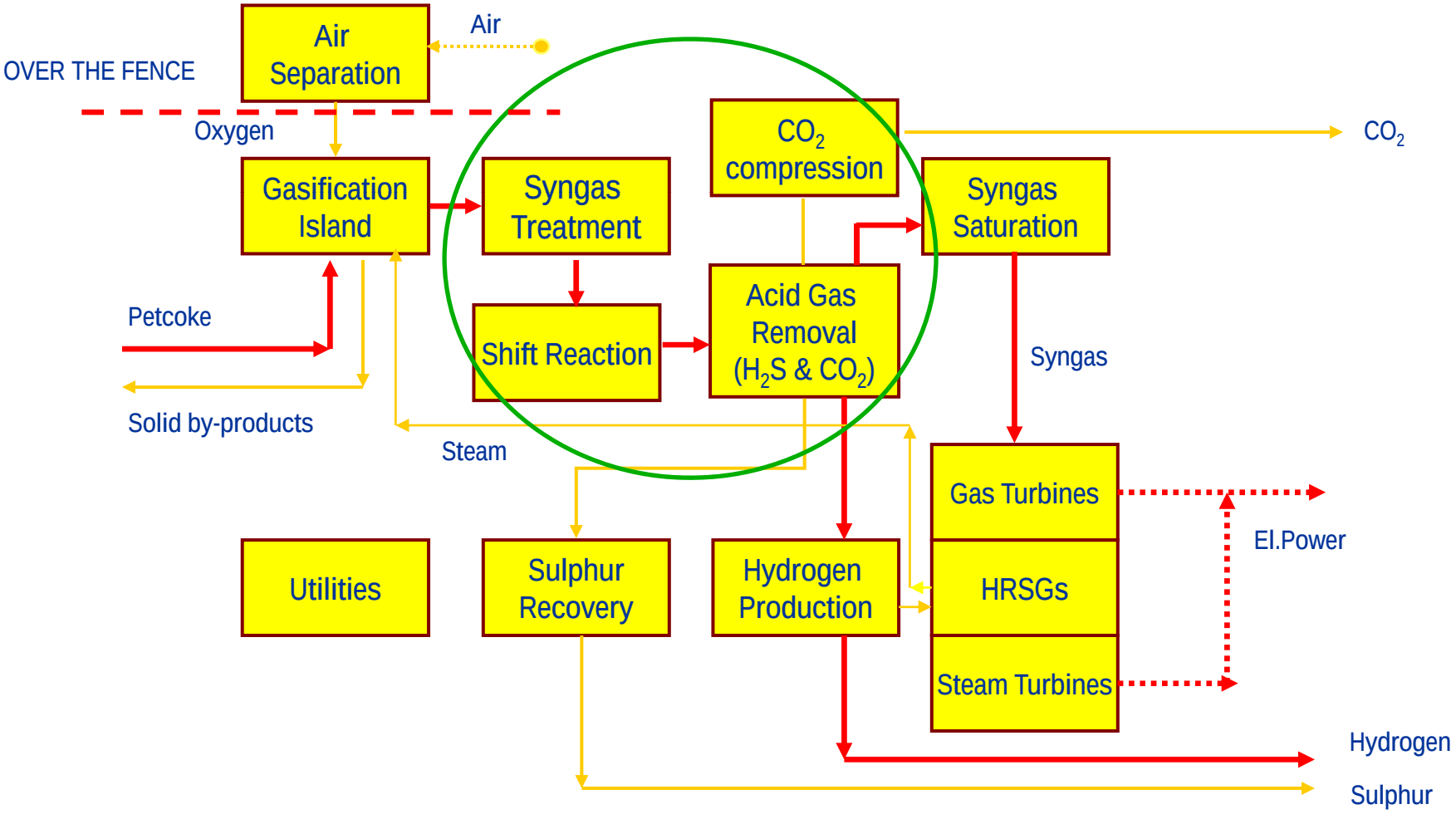
**REQUIRED INSTALLATION :**

- **New water-gas shift conversion unit (2 stages)**
- **New AGR Unit (possible re-use of $H_2S$ absorber and regenerator)**
- **New $CO_2$ drying and compression unit**
- **Modification to gas turbine burners**
- **Implementation of SCR in HRSGs ($NO_x$ Control)**

**REQUIRED CHECK :**

- **Possible by-pass membrane of hydrogen production unit**
- **Sulphur recovery unit**
- **Nitrogen/steam injection alternative to SCR**
- **Cooling water system**

# ALTERNATIVE 2 - $CO_2$ Maximum Capture Cases/ Increase of $CO_2$ content by means of shift reaction



# IGCC Performance

| | | |
|---|---|---|
| Gasification Feed Flowrate | t/h | 152 |
| Syngas Thermal Power (gasification scrubber outlet) | MWth | 1,474 |
| Hydrogen Production | MWth | 180 |
| Steam Export | MWth | 142.1 |

| | | | ALT. 1 | ALT. 2 |
|---|---|---|---|---|
| Power Output from 1 GT | MWe | 135 | 132.4 | 132.5 |
| Power Output from 1 ST | MWe | 59.7 | 57.4 | 46.97 |
| Gross Power Output | MWe | 584.1 | 569.4 | 538.4 |
| Power Consumption | MWe | 63.8 | 93.5 | 112.1 |
| Net Electric Power Produced | MWe | 520.3 | 476 | 426.3 |
| Net Electric Power difference | MWe | | - 44.4 | - 94.0 |
| $CO_2$ captured | t/h | | 84.6 | 442.9 |
| $CO_2$ capture rate | % | | ~16 | ~85 |
| Loss of Power over carbon capture | kWt/$CO_2$ | | 0.52 | 0.21 |

| | | ALTERNATIVE 1 | ALTERNATIVE 2 |
|---|---|---|---|
| $CO_2$ captured | t/year | 680,000 | 3,550,000 |
| Net Electric Power Reduction | MW | 44.4 | 94 |
| Electric Power for capture | MW/t $CO_2$ | 0.52 | 0.21 |
| Electric Power Cost for Capture (*) | €/t $CO_2$ | 44.2 | 17.9 |

*(*) based on 85 €/MWh*

## Preliminary costs have been evaluated. Further investigation is required to better define the investment cost

- **Revamping of the existing unit versus grass roots**
- **Impact on the other units**
- **Transportation and storage to be investigated**

# CONCLUSIONS

- **$CO_2$ market and power scenario have significant impact on the economics – high cost of electricity will penalize the redditivity**
- **$CO_2$ minimum capture appears not to be attractive**
- **$CO_2$ maximum capture can be viable**
- **$CO_2$ capture decreases efficiency by 10 % and power output by 18 %**
- **Role of political and legislative issues (EU Directives – State Member approach-incentives)**

# THANK YOU

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