TriGen, an innovative oxy-fuel technology to convert high CO_2 gas reserves into power

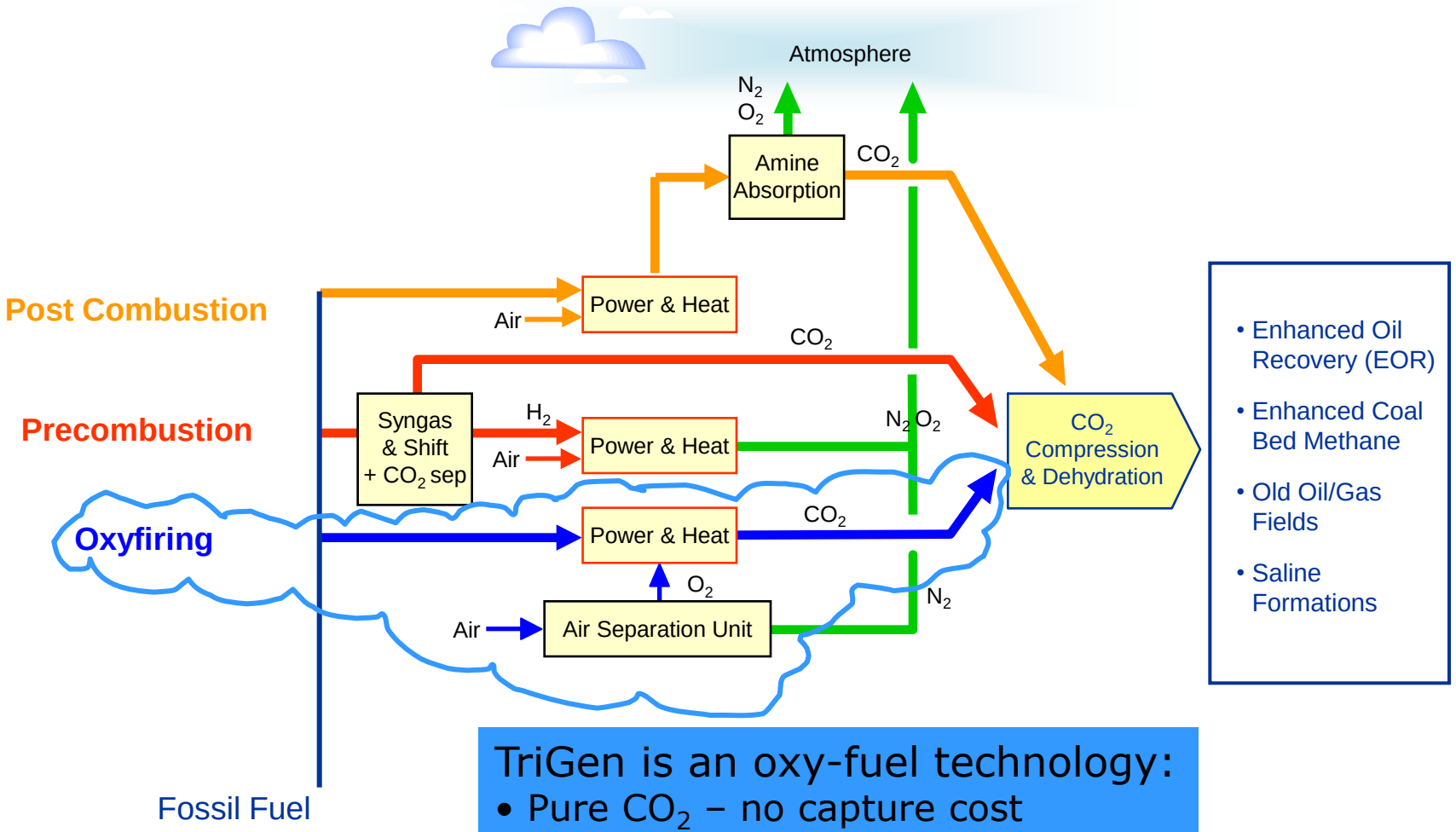
P.Kapteijn Dir. Technology & Innovation, Maersk Oil,
C.Biebuyck CES and E.Kutscha Siemens OG

IGRC Conference, Seoul, 19 October 2011

TriGen Presentation

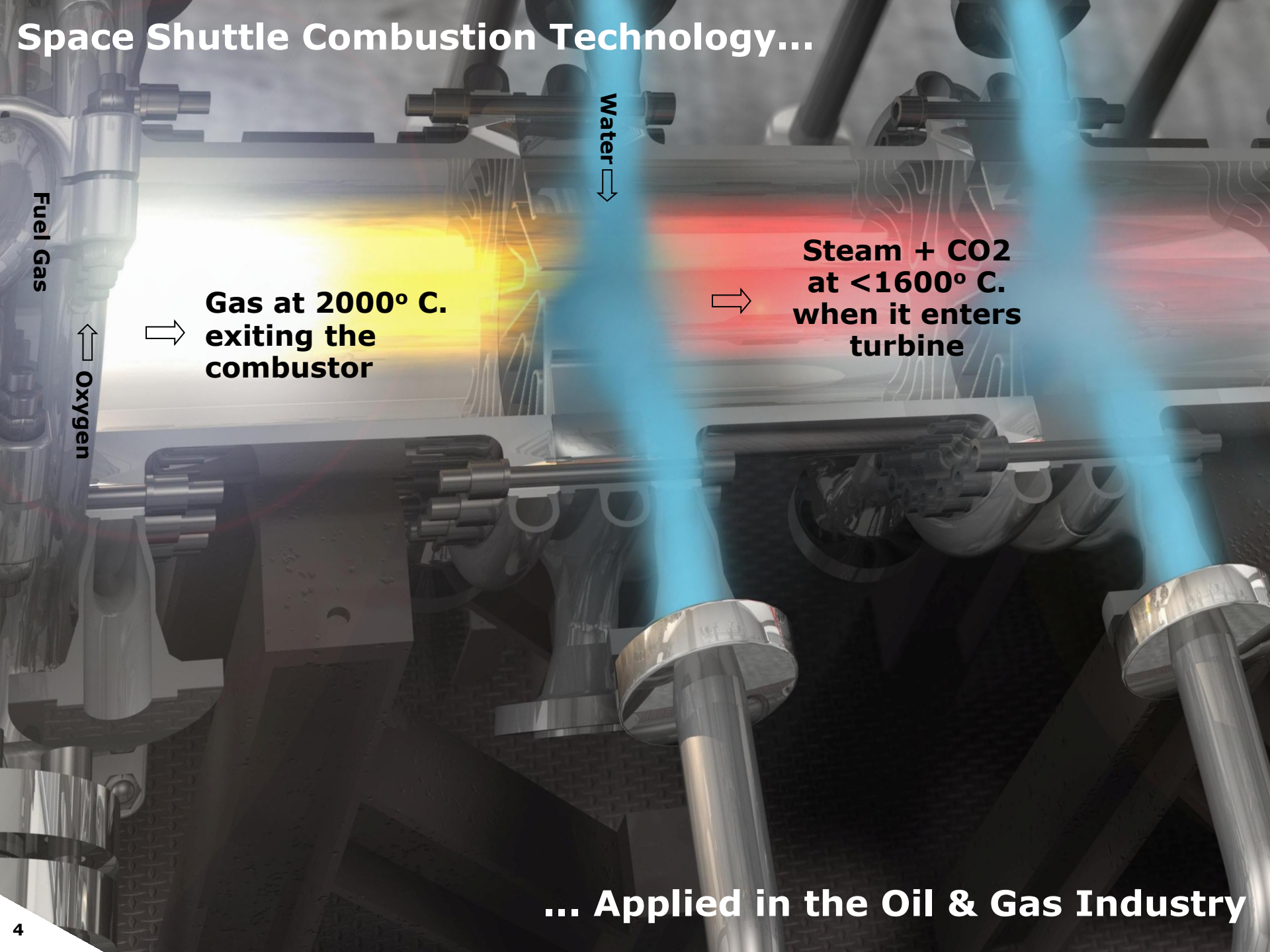
- TriGen Oxy-Fuel Technology
- Novel Energy Value Chains
- Stranded Gas and Electric Power
- Conclusions

Principal CO_2 Capture and Use Concepts



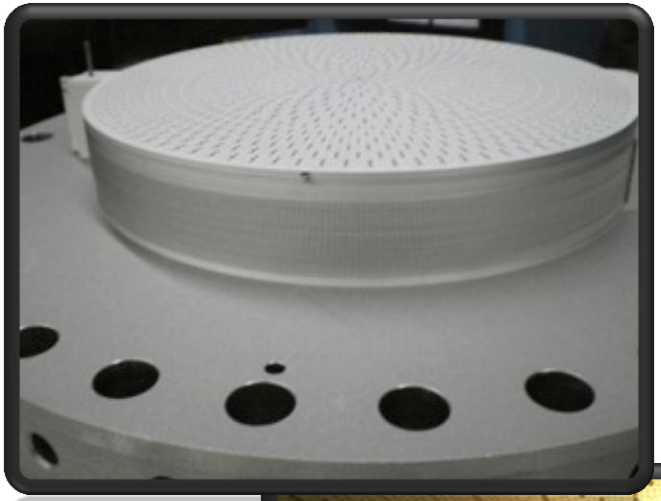
TriGen is an oxy-fuel technology:
- Pure CO_2 – no capture cost
- Air Separation = energy penalty

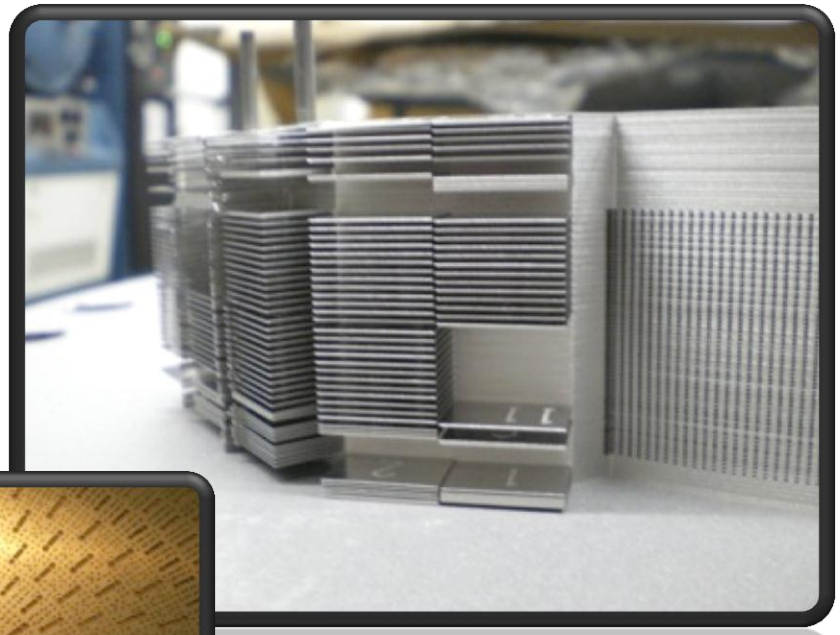
Space Shuttle Combustion Technology…

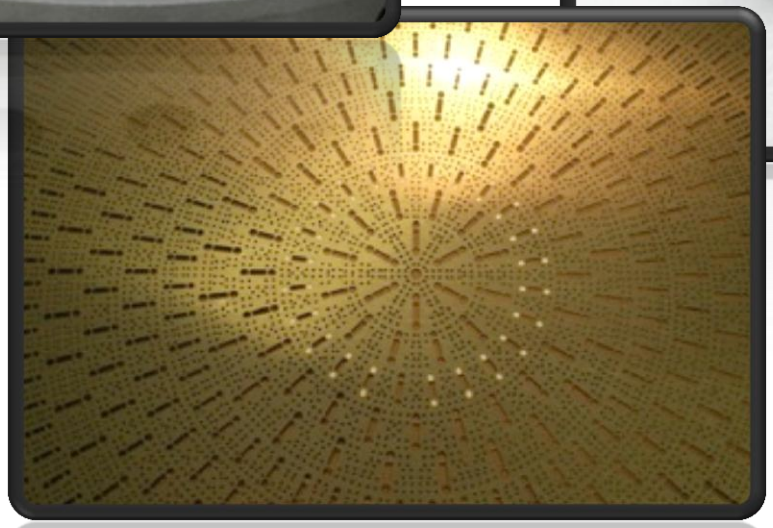


… Applied in the Oil & Gas Industry

CES Platelet Technology







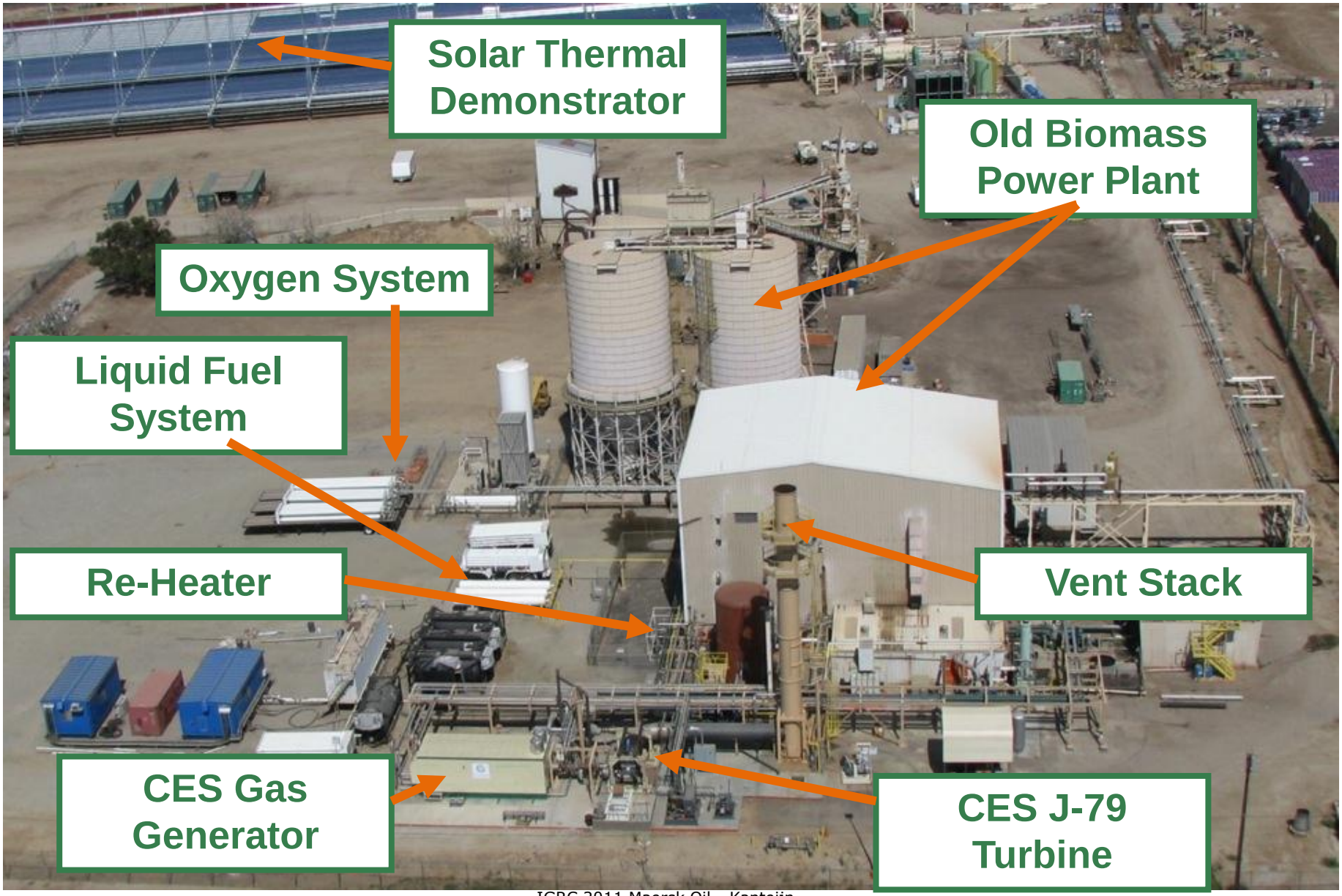
Platelet technology used for injector design – Promotes intimate mixing and cooling

12” Gas Generator

Compact Power – 200MW$_{th}$ – 100% Conversion

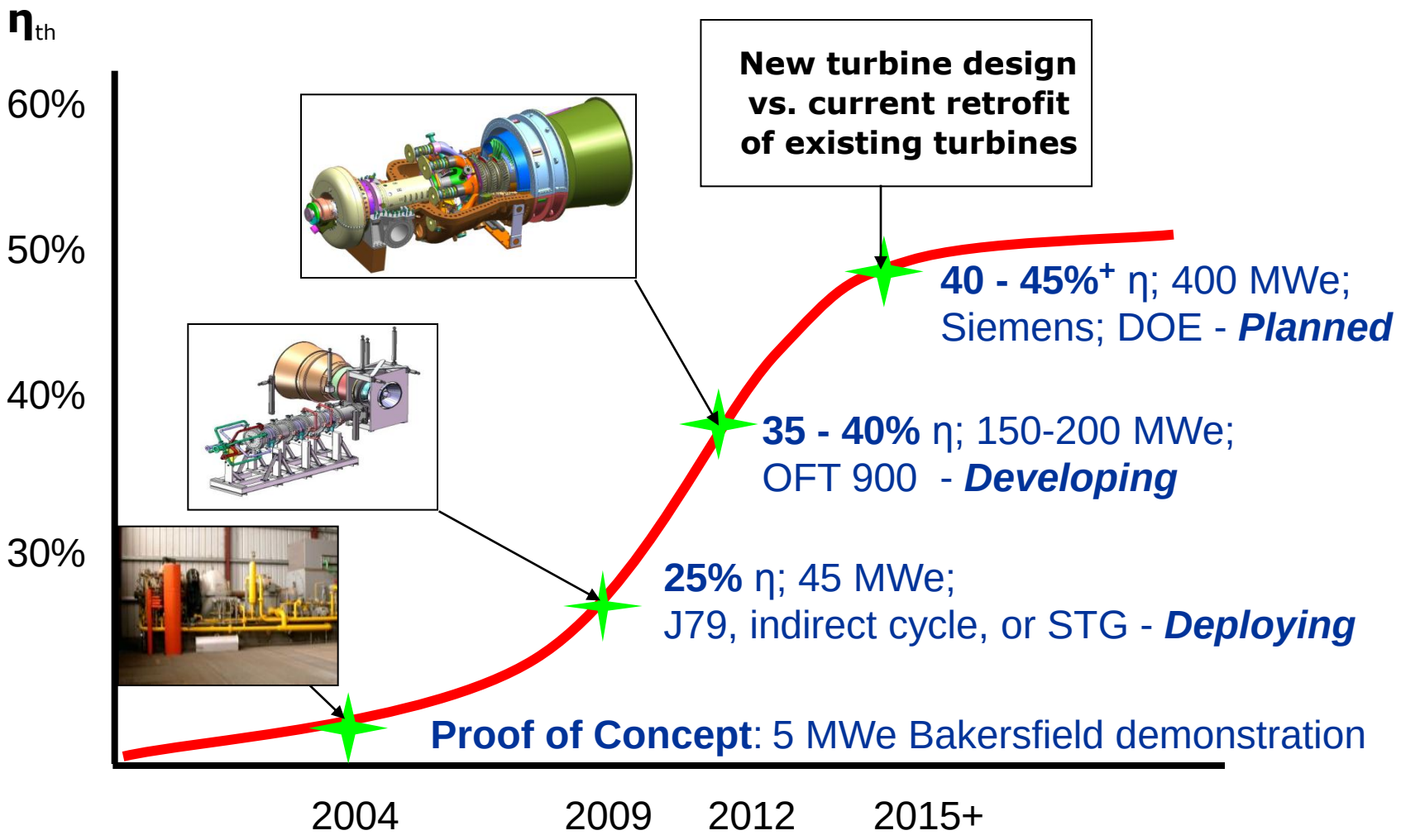
MAERSK OIL

CES Kimberlina: World's Largest Oxy-fuel Facility



OxyFuel Turbine Development

Scaling up and increasing operating temperature and pressure



Note: Efficiencies shown are natural gas (LHV) basis

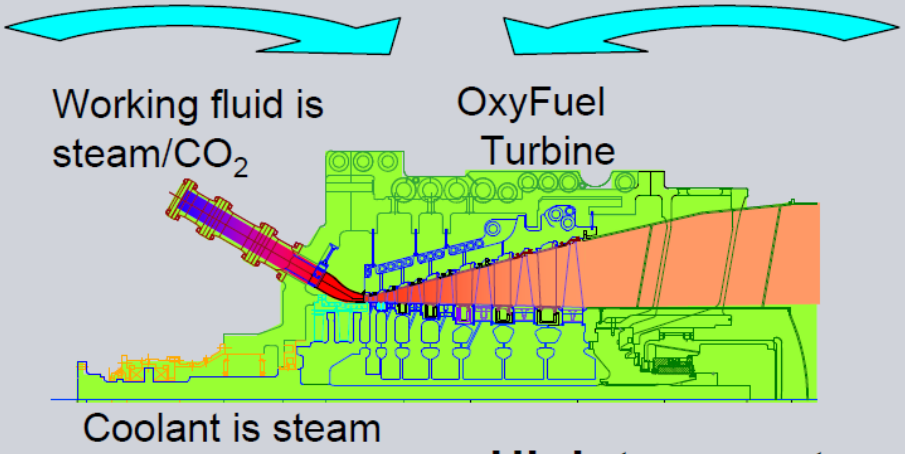
Oxyfuel Turbine - Development

- The combustor technology requires an altered turbine to be developed……

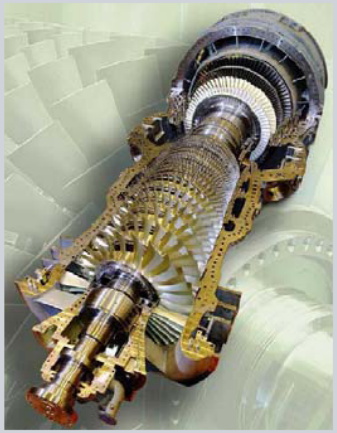
Turbine is Not Specifically a Steam Turbine or a Gas Turbine

… but has some character of both

Steam Turbine



Gas Turbine



Working fluid

- No air (nitrogen)
- H_2O concentration
- High heat capacity

- High temperature environment
  - Cooled turbine components
  - Secondary flow system
    - Cooling & leakage
  - Advanced materials & coatings

Projects Have Attracted Public Funding

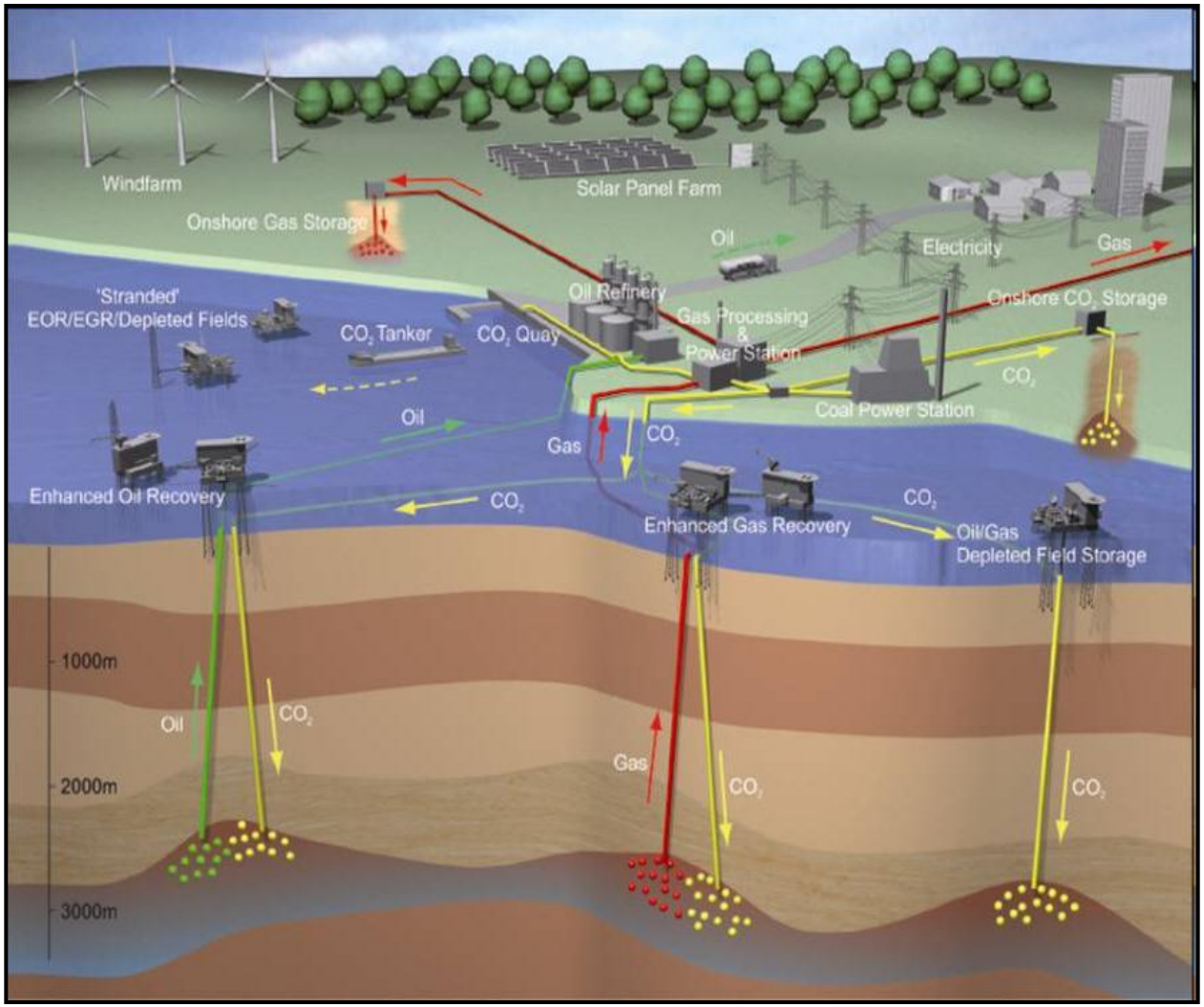
Placerita, US, DOE Funding (2011)

- Complete development of OFT-900 turbine for commercial deployment
- Testing of various fuels
- US$ 30 million from DOE, US$ 12 million funding from CES

Pegasus, the Netherlands (2012)

- Run TriGen unit continuously (2x 2000 hrs)
- Located in IJmuiden, NL at Tata Steel Mill
- GEJ79 based, 12MWe
- US$ 22 million funding from Dutch Government
- Additional funding is US$ 43 million from:
  Maersk Oil, Siemens, Linde, CES, SEQ, Tata Steel
- Phase II planned for 340 MWe (>2015)

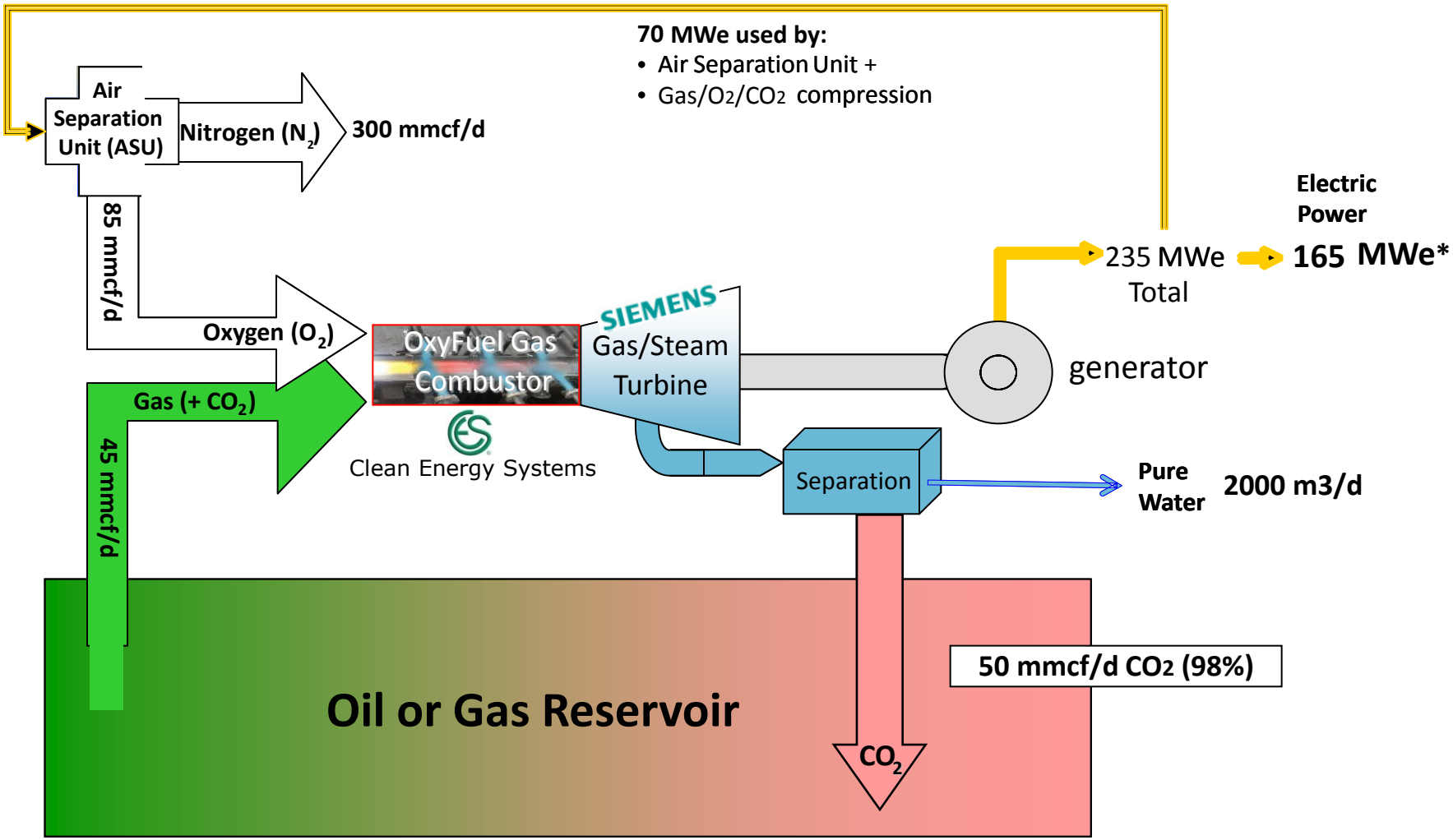
Integration of Oil & Gas and CO_2 Systems



- Low cost CO_2 for Enhanced Oil Recovery (EOR)
- Combination with sequestration (CCS)
- Zero emission power from fossil fuels
- Need for systems and lifecycle design approach

TriGen for Upstream Oil and Gas: Principles

Converting (low quality) hydrocarbons into electricity, CO_2 and water



Technology Partners

SIEMENS

MAERSK OIL

TriGen: Multiple Sources of Value

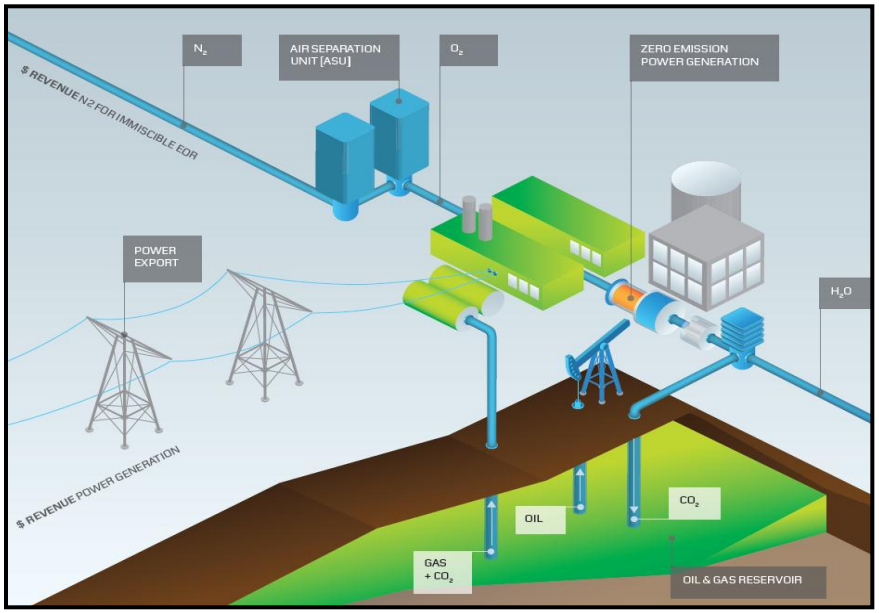
***Main Value Streams*:**

- **"Green" power**

  – near zero CO_2 footprint

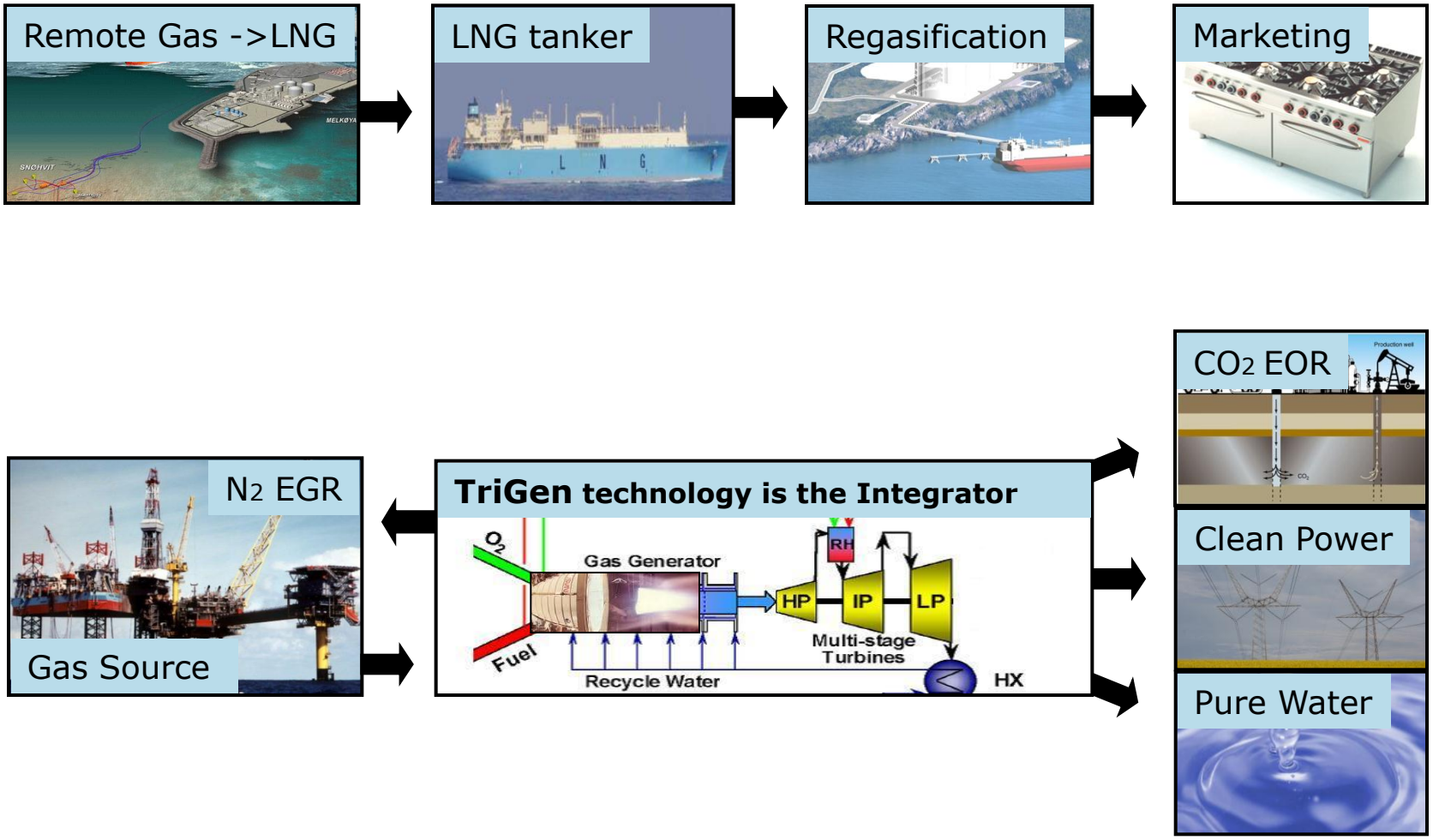
- **Pure CO_2** – low cost for EOR
- **Fresh, boiler quality water**

  ~60,000 bpd for 800 MW plant



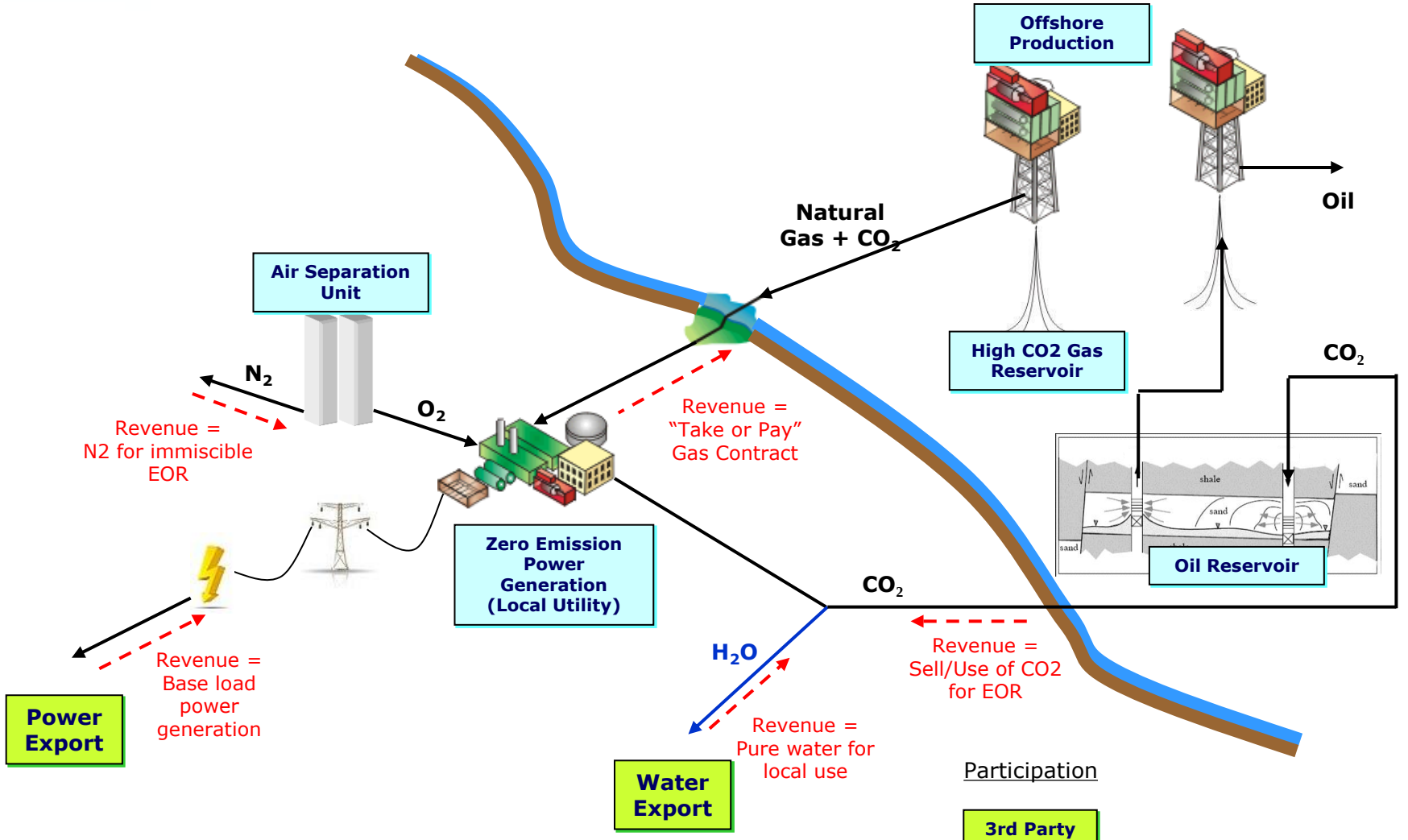
- **Produces N_2** ~1.0 Bscfd for 800 MW plant
  - can be used for immiscible/deep miscible EOR or EGR
- **Low grade heat** – can be used for de-salination
- **Enables different CO2 EOR design/operation**
- **Carbon Credits** (where applicable)

Integration Across the Gas Value Chain…



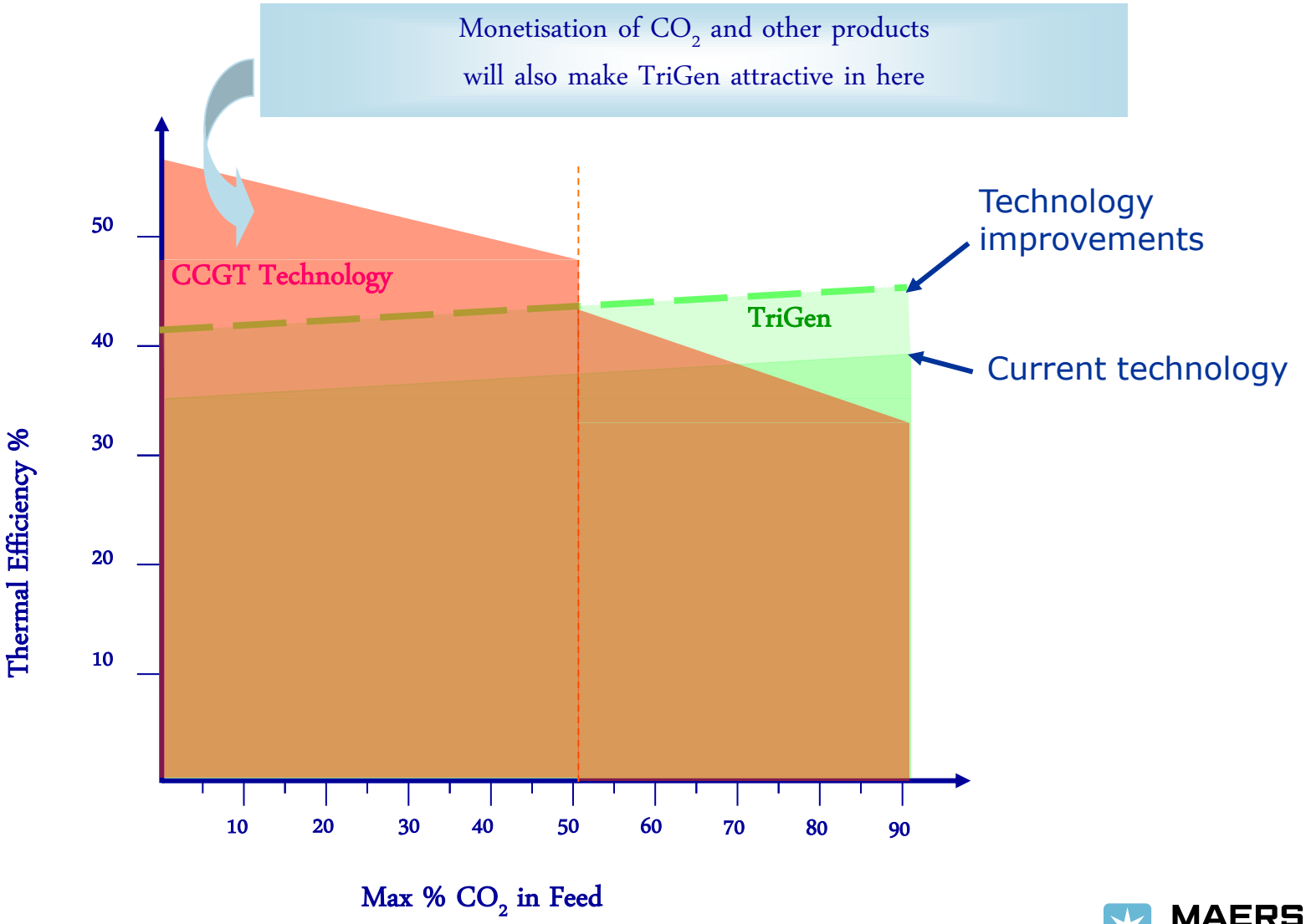
…makes the most of national and global resources

Stranded Gas Development Offshore with EOR

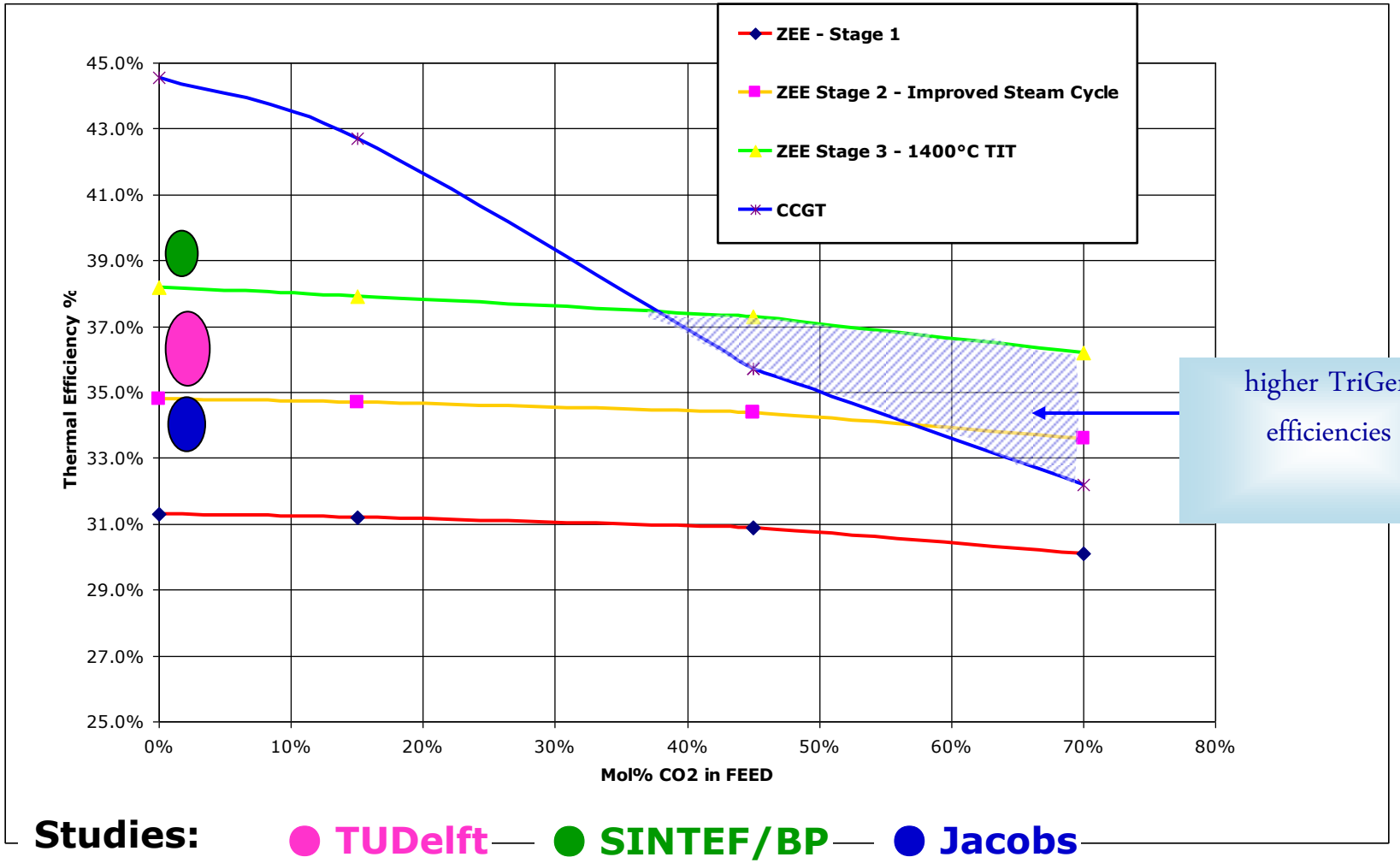


Commercial and Partnership Design?

TriGen vs CCGT – no CO_2 capture

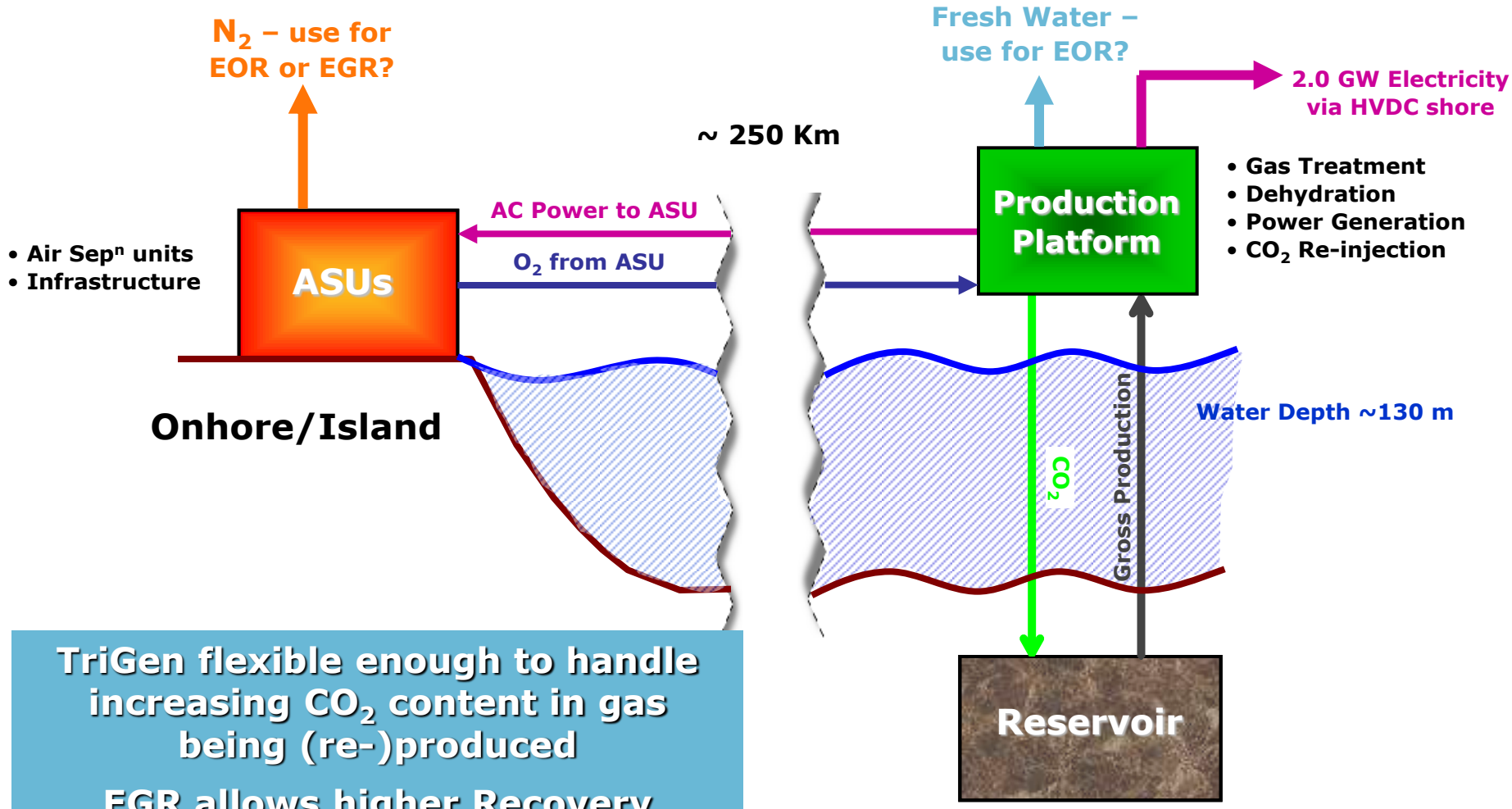


TriGen vs CCGT – with CO_2 capture



Example – TriGen Scheme Offshore

Onshore ASU, Offshore Power Generation + CO_2 Re-injection

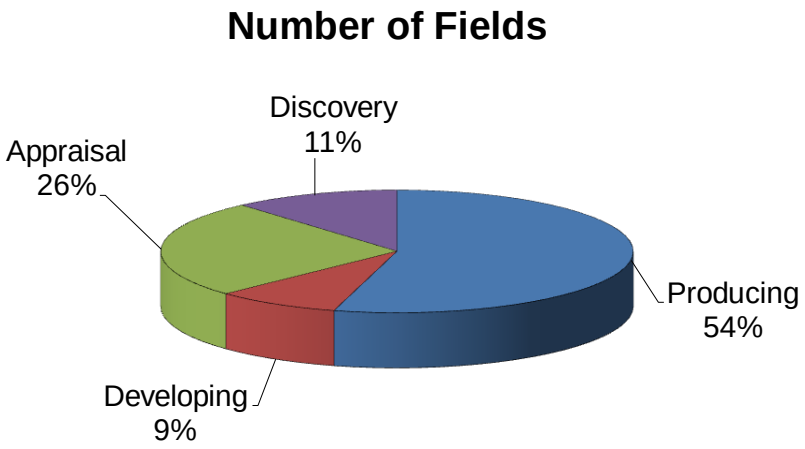


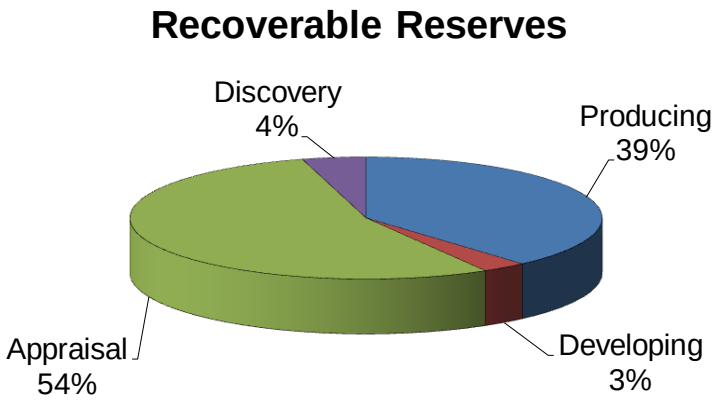
TriGen flexible enough to handle increasing CO_2 content in gas being (re-)produced

EGR allows higher Recovery

Potential in High CO_2 Gas Fields in Asia-Pacific

- **35 fields have CO_2 content of 20%–75%:**
  - **20% – 39% CO_2: 22 fields**
  - **40% – 59% CO_2: 6 fields**
  - **60% – 75% CO_2: 7 fields**
- **16 out of those 35 fields are undeveloped (discovery, appraisal, and developing status):**
  - **20% – 39% CO2: 5 fields**
  - **40% – 59% CO2: 5 fields**
  - **60% – 75% CO2: 6 fields**
- **Total undeveloped recoverable gas reserves amounts to ~67 tcf.**
  - **20% – 39% CO2: 10 tcf**
  - **40% – 59% CO2: 6 tcf**
  - **60% – 75% CO2: 51 tcf**





Note: Not included in these statistics are 3 gas fields with CO_2 content >75% and EUR ≥ 500 bcf (J-5 in Malaysia, Kuala Langsa in Indonesia, and Champion in Brunei)

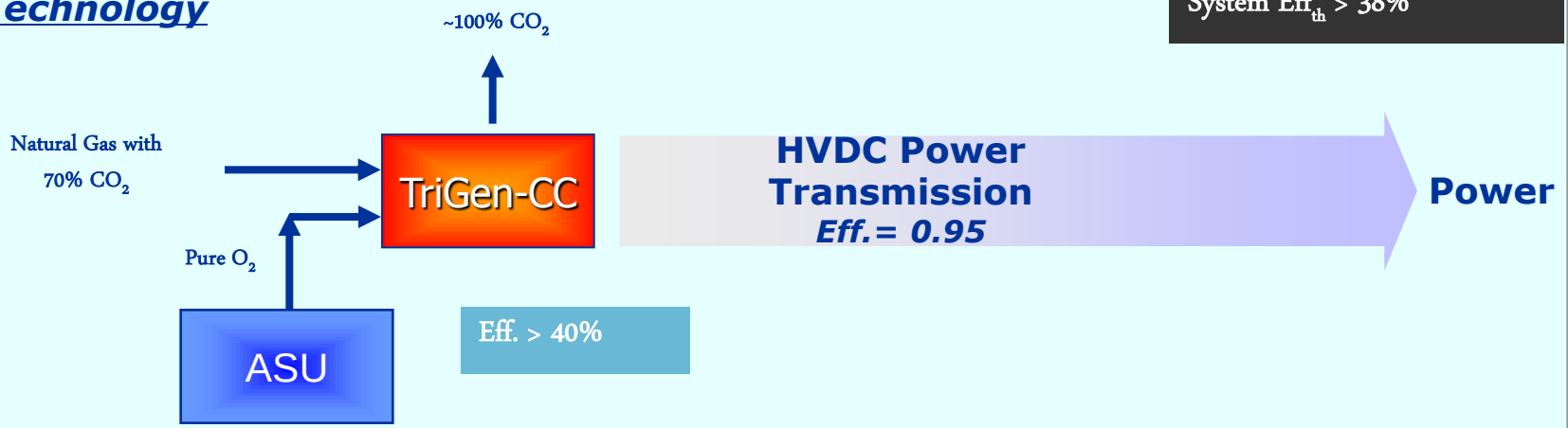
TriGen vs LNG for To "Stranded Gas"

Conventional Scrubbing + LNG Technology

System Eff_{th} < 38%

TriGen Technology

System Eff_{th} > 38%



Comparison: TriGen has better efficiency and lower emission

- No loss of heavy HC for TriGen

Conclusions

1. For stranded gas fields with >50% CO2, TriGen offers a commercially viable, zero emission development option
   - lower cost development phases than LNG, higher recovery
   - but… lower commercial flexibility: connected to grid

2. Optimum TriGen configuration for offshore gas fields depends on reservoir, distance to dry land and power consumers
   - Location of ASUs, HVDC equipment, water-depth, reservoir etc.

3. TriGen based projects require a holistic, integrated approach to (national/regional) energy and resource management
   - Commercial terms and regulations for integrated chains
   - Combination with EOR, multiple partners
   - Valuation of emission reduction, carbon credits