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CASE STUDY

Multifunctional Energy Systems for Arctic Offshore Oilfields*

This case study examines the use of CHEMCAD process simulation software to design and evaluate multifunctional energy systems for Arctic offshore oilfields. The systems integrate power generation, waste-heat recovery, and carbon dioxide capture and compression to support enhanced oil recovery (EOR) while addressing the severe energy and environmental constraints of Arctic operations.

The simulated systems were developed for offshore platforms processing associated petroleum gas (APG) and producing supercritical CO_2 for oil recovery, sequestration, and platform energy supply.

CHALLENGE

Arctic offshore oil production faces several interrelated challenges:

- Extreme climatic conditions and remote locations far from energy infrastructure
- Strict environmental requirements to protect a fragile ecosystem
- Low efficiency of conventional single-purpose power systems
- The need to simultaneously improve oil recovery, reduce emissions, and ensure platform self-sufficiency

Traditional energy solutions address these issues individually, often resulting in higher fuel consumption, lower efficiency, and increased operational complexity. The challenge was to determine whether a single, integrated technological system, evaluated using CHEMCAD, could deliver higher efficiency and multiple operational benefits at once.

SOLUTION

CHEMCAD was used as the core simulation and analysis platform to model and compare multifunctional power systems.

- Steady-state simulation of fully integrated process schemes
- Modeling of Brayton-cycle gas turbines combined with Rankine cycles (low-boiling working fluid or steam)
- Integration of a CO_2 capture and compression module producing supercritical CO_2 at 20 MPa and 200 °C
- Application of a CHEMCAD-compatible Exergy Unit to calculate:
    - Exergy balance
    - Exergy losses
    - Overall exergy efficiency

The CHEMCAD simulations enabled direct comparison between the proposed system and an existing multifunctional reference system (VENZ-4), using identical operating assumptions and thermodynamic criteria.

**Adapted from Naletov et al., 2021, IOP Conference Series: Earth and Environmental Science, Vol. 678, Article 012023*

RESULTS

Key results for a pilot plant processing 3500 Nm^3/hr of associated petroleum gas include:

CHEMCAD simulations showed that the integrated Brayton–Rankine systems significantly outperformed the reference technology.

- Higher net power output due to waste-heat recovery
- Increased CO_2 production suitable for EOR and sequestration
- Improved exergy efficiency across all configurations
- CO_2 compression energy demand below 10% of total power generated, confirming feasibility of integrated EOR support

REPRESENTATIVE CHEMCAD RESULTS

PARAMETER	REFERENCE SYSTEM (VENZ-4)	CHEMCAD-OPTIMIZED SYSTEM
Associated Gas Flowrate	1,875 Nm^3/hr	3,500 Nm^3/hr
CO_2 Production	98–128 t/day (liquid)	≈ 203 t/day (supercritical)
Net Power Output	8–9.5 MW	≈ 13.7 MW
Exergy Efficiency	≈ 49.8 %	52.2–67.3 %

These results demonstrate that CHEMCAD-based process integration enables measurable efficiency gains while supporting CO_2-EOR operations.

TANGIBLE BENEFITS

The CHEMCAD-driven solution delivered clear, quantifiable advantages:

- Higher energy efficiency through integrated Brayton–Rankine cycle design
- Improved oil recovery potential via on-site production of supercritical CO_2
- Reduced emissions by utilizing associated petroleum gas instead of flaring
- Lower operational complexity by combining multiple functions into one system
- Scalable and low-maintenance design suitable for remote Arctic offshore platforms

Overall, CHEMCAD enabled a single, optimized multifunctional system that simultaneously addresses energy supply, environmental protection, and enhanced oil recovery.

FIGURE 1 - Schematic diagram of the technological solution with Rankine cycle