

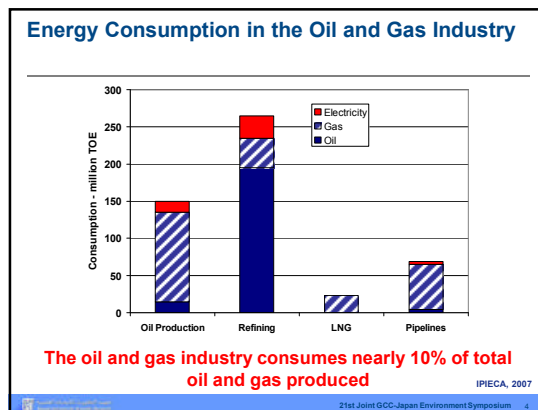
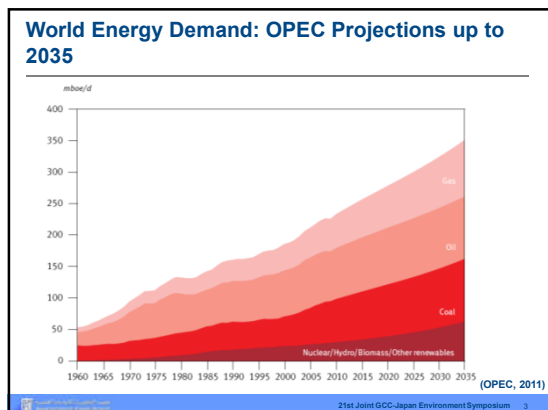
Application of Renewable Energy in the Petroleum Industry

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21st Joint GCC-Japan Environment Symposium
(The 2nd Joint Qatar-Japan Environment Symposium)
"Sustainable Environment, Climate Change & Renewable Energy for Oil and Gas Industry"
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Outline

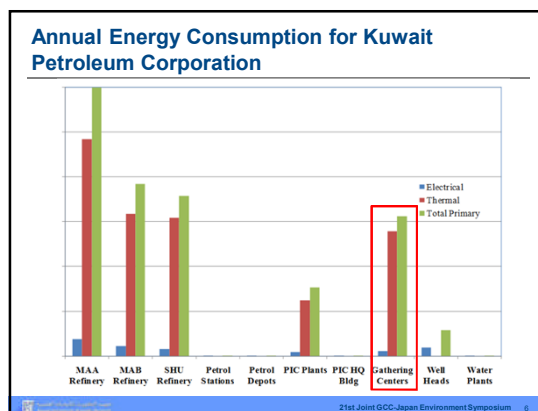
- World Oil and Gas Demand
- Energy Demand of Oil and Gas Industries
- Key Solar Applications in Oil and Gas Industries
- Conclusion



Energy Scene Up to 2035/2040

- ❖ By 2035-2040, total energy demand will increase by nearly 50% of the present level
- ❖ Fossil fuels (oil, gas, and coal) will remain to be the dominating primary energy sources at over 82%, and reserves will remain significant
- ❖ 10% of energy produced (oil or gas) is consumed for oil or gas production and processing
- ❖ Environmental issues are serious drivers to utilize renewables sources in oil and petroleum processing

To meet **very long-term** energy demand, we need to be **more efficient in oil production and processing**




Characteristics of Energy Usage in the Petroleum Industry


- Main forms of energy usage:
 - ❖ Thermal energy (over 93%):
 - Direct fuel
 - Steam
 - ❖ Electricity (around 7%): machine drive
- Refineries and petrochemical plants have high energy density (kWh/m^2)
- Upstream processing (i.e., gathering centers) have lower energy density (kWh/m^2)

Current Solar Applications in the Upstream Industry

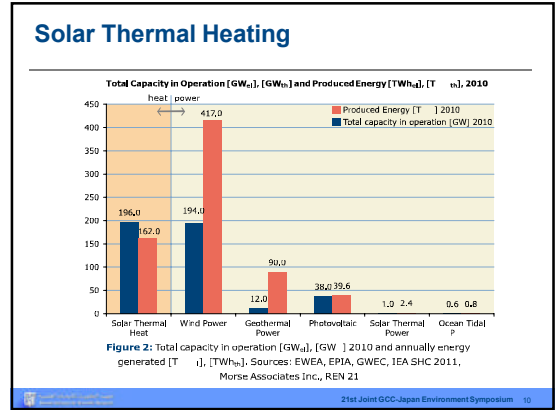
- Uninterruptable power systems (UPSs)
- Flow monitoring
- Navigation aids
- Telecommunication
- Tank gauging
- Drilling meters
- SCADA equipment
- Remote telemetry units (RTUs)
- Field laboratories
- Safety and emergency lighting
- Seismic monitoring
- Battery chargers
- Control valves



Solarmine PV Plant at the Chevron Midway-Sunset Oil Field – In Operation Since 2003

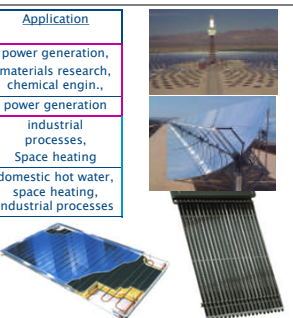


Flexible amorphous-silicon solar PV plant, with a capacity of 490 kWAC. The plant consisted of 4,800 panels and extended over 6 acres. It was connected to the local electric distribution grid to supplement required power



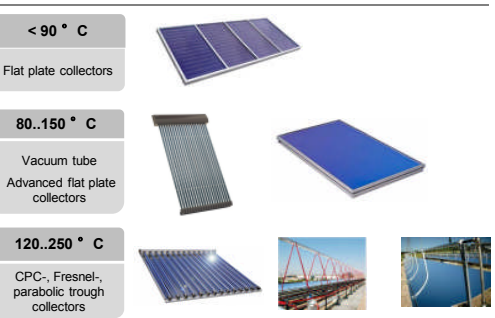
Technologies for Solar Thermal Energy Utilization

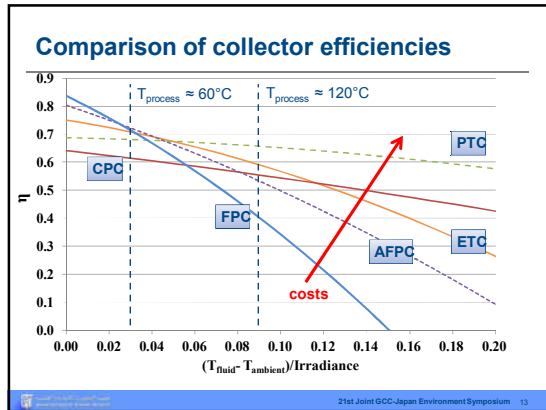
Collector	Temperature in °C	Application
concentrating	> 1000	power generation, materials research, chemical engin.,
	≈ 400	power generation
Vacuum tubes	80 ... 150	industrial processes, Space heating
Flat plate collectors	30 ... 90	domestic hot water, space heating, industrial processes



Collectors for process heat applications

- < 90 ° C
 - Flat plate collectors
- 80..150 ° C
 - Vacuum tube
 - Advanced flat plate collectors
- 120..250 ° C
 - CPC-, Fresnel-, parabolic trough collectors





Future Applications of Solar Energy in Upstream

Concentrated Solar Energy in Enhanced Oil Recovery (EOR)

- ❖ Steam temperature requirements for enhanced oil recovery: 115-300°C
- ❖ Natural gas is currently the predominant fuel used to generate steam, but it is rapidly becoming expensive due to short-falling supply
- ❖ Alternative fossil fuels could be used, but CO₂ emission is an issue (CO₂ sequestration could be used at significant cost).
- ❖ The use of concentrated solar energy can provide huge monetary savings, and provide significant reduction of CO₂ in oil production.

**Solar steam is competitive costing
\$3.00 per million BTU**

Daniel Kraemer, Applied Energy 86 (2009) 1437-1441

Anticipated Solar Projects for EOR

- ❖ Chevron is building a demonstration plant with a capacity of 29 MWth. Steam is generated by tower technology.
- ❖ In GCC countries, PDO/Oman is constructing a concentrated solar thermal pilot plant integrated with the conventional steam plant with a capacity of around 220 ton.

The GCC has the potential to be a prime market for solar steam extraction of heavy oil due to high solar radiation



Electroplating Steinbach & Vollmann

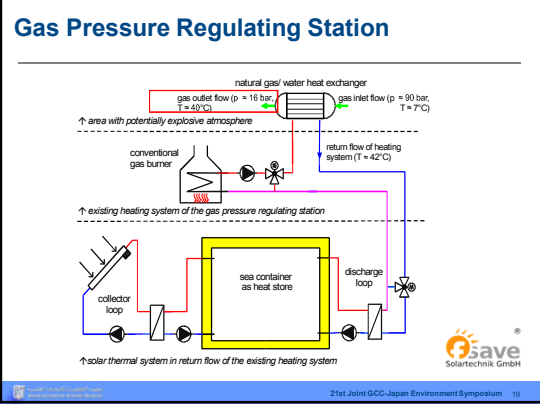
ETC, 400 m²
Solar preheater for electroplating (70 °C)

The image shows a large array of solar collectors (ETC) installed on a roof. The collectors are arranged in rows and are used for preheating water for electroplating. The temperature of the preheated water is 70 °C.

Food processing - Edmund Merl GmbH

- Hot water demand for food production $\approx 30 \text{ m}^3/\text{d}$, 60°C
- 568 m² flat plate collectors

The image shows a building with a large array of flat plate solar collectors installed on its roof. The collectors are used for hot water demand in food processing. The hot water demand is approximately 30 m³/d at 60°C, and the array consists of 568 m² of flat plate collectors.



- ### Conclusions
- ❖ Solar thermal technologies, especially low and medium temperature systems are proven and excellent candidate for integration with oil and gas industries.
 - ❖ Downstream oil and gas are energy intensive. However, they usually lack space for solar collectors.
 - ❖ Upstream pose as an attractive candidate for integration with solar systems.
 - ❖ Integrating solar energy with operation will reduce operating cost and reduce green-house gases emission significantly

Acknowledgements

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Thank you