New CO_2 Utilization in the Oil & Gas Sector

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Workshop on Deployment of Carbon Capture, Use and Storage in the Arab Region – Challenges and Opportunities

Some CO_2 Utilizations

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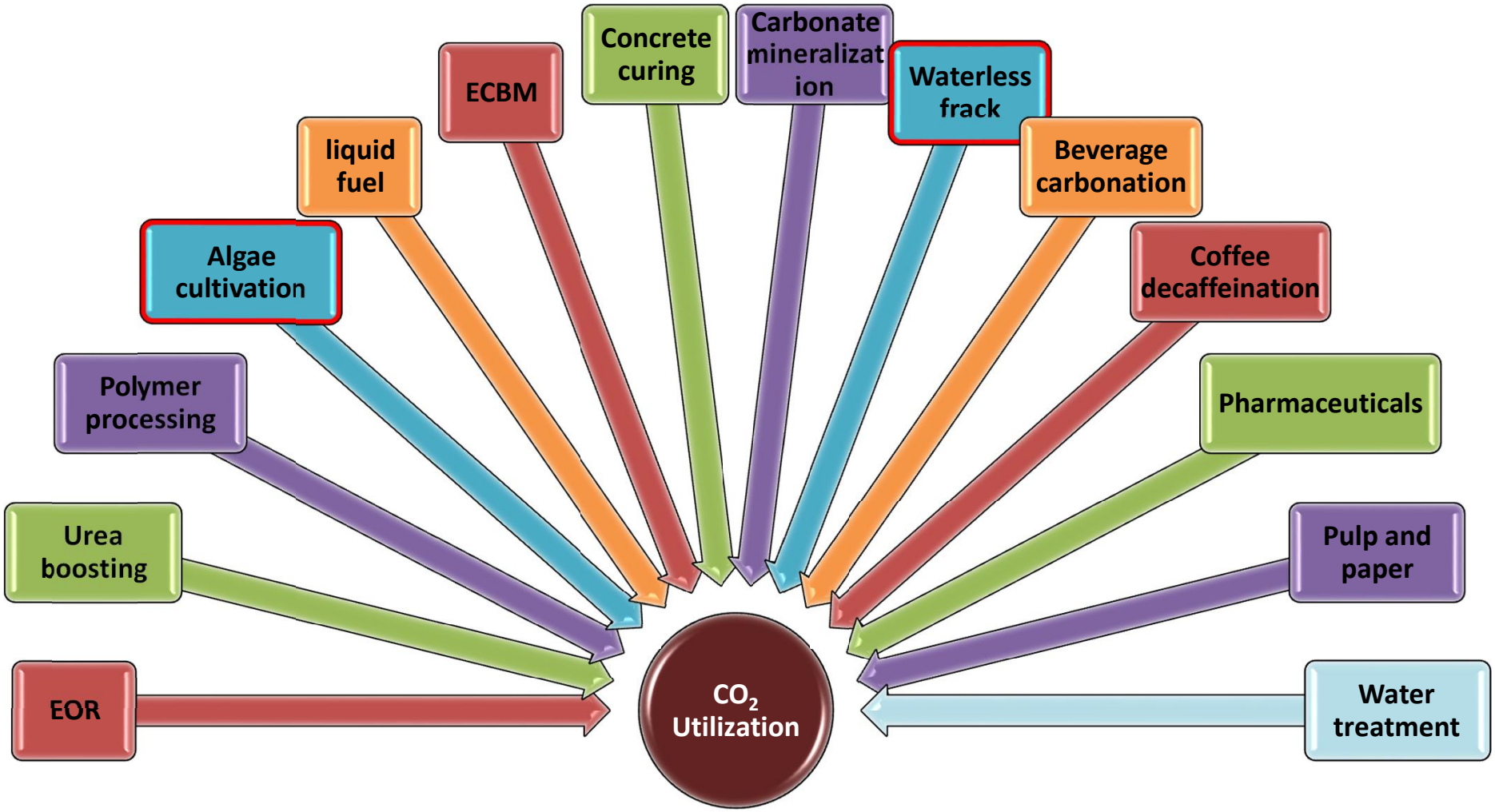

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Algae Cultivation



Algae – Definition and Benefits

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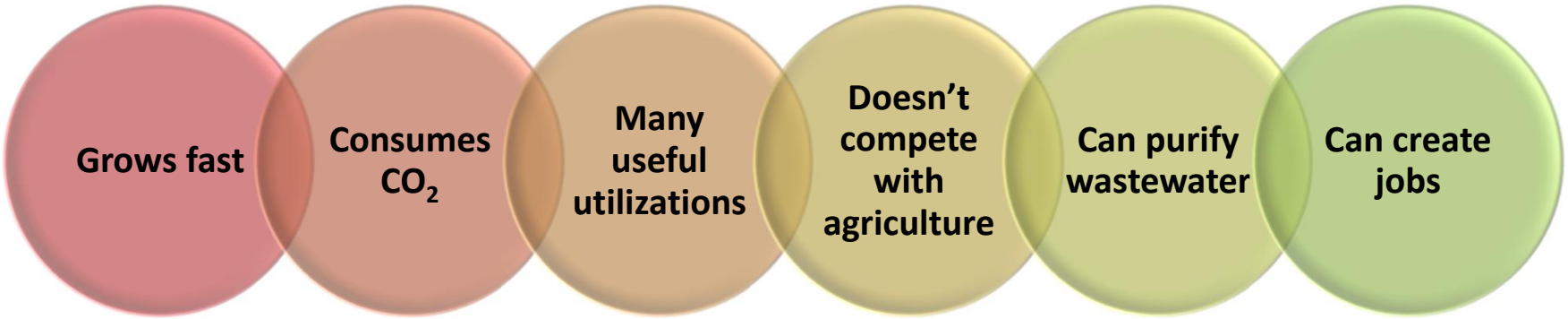
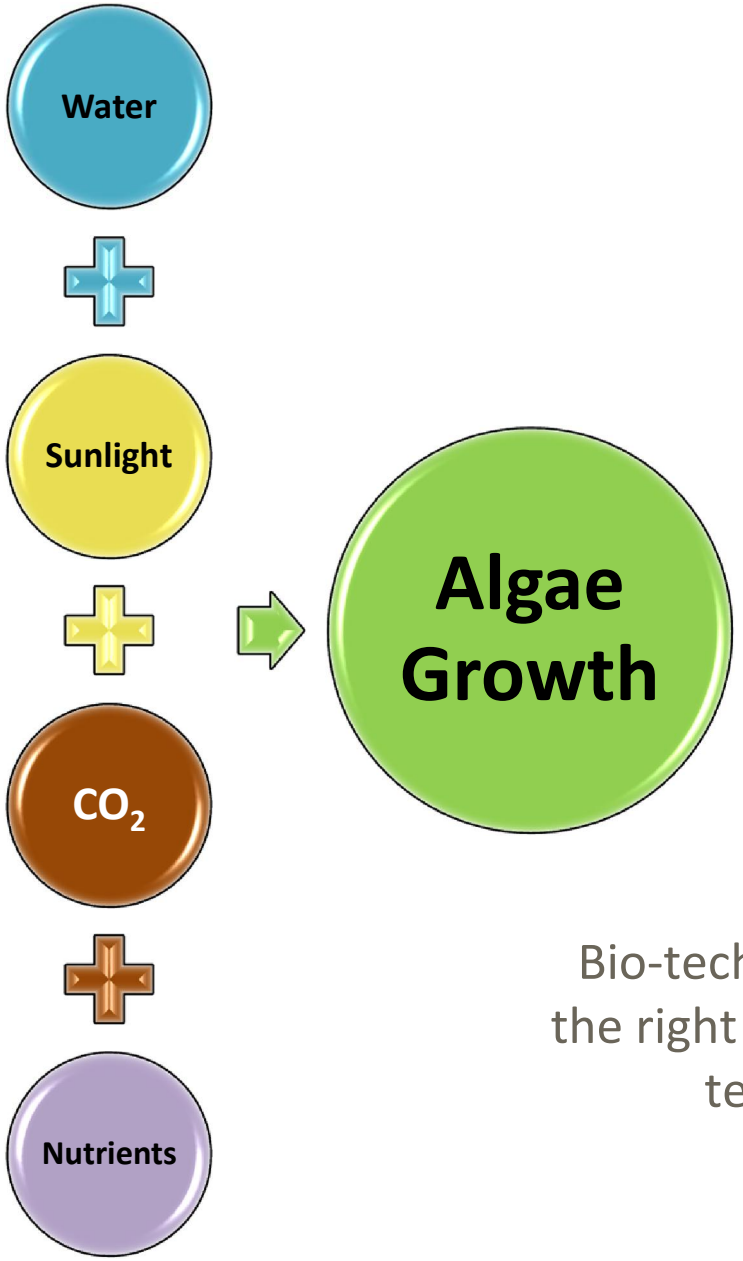
What are Algae

Algae are simple plants that can range from the microscopic (microalgae), to large seaweeds (macroalgae), such as giant kelp more than one hundred feet in length. Microalgae include both cyanobacteria, (similar to bacteria, and formerly called “blue-green algae”) as well as green, brown and red algae.

Why Algae



What Do Algae Need to Grow



In an Oil & Gas Context ….

- Water can be from that produced with hydrocarbons
- Sunlight is abundant in the Arab World
- CO_2 – Captured
- Nutrients can be present in the produced water or can be added

Bio-technology can be used to select/produce the right algae for a specific application (salinity, temperature, water contents, etc)

What Does Algae Cultivation Look Like

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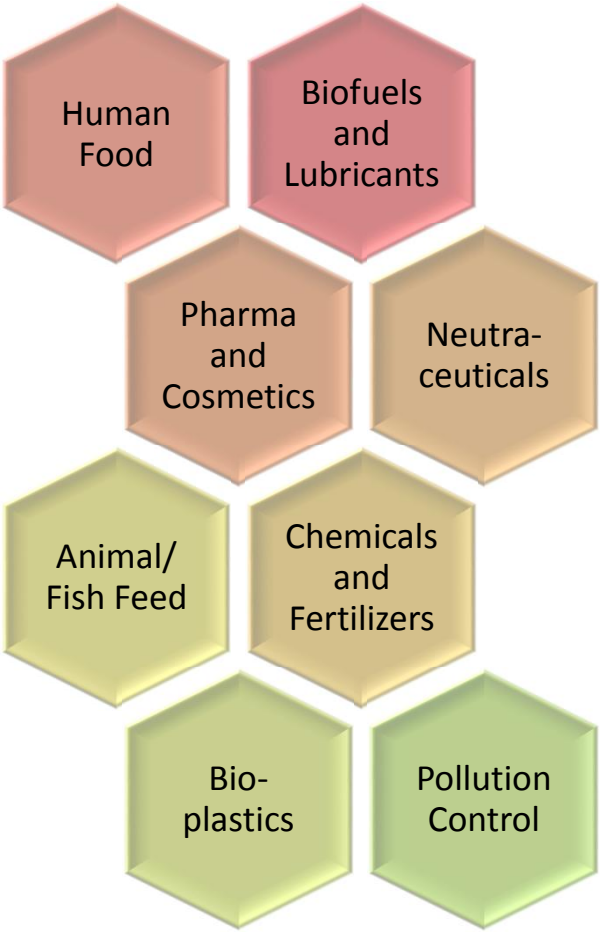
Photobioreactors for algae cultivation. Left: High Rate Algal Ponds, Earth Rise Farms, USA. Right: Tubular photobioreactor developed by IGV, Potsdam, Germany.

Algae Products and Value



Category	*Price Range ($/Kg)*
Biofuels	<1
Proteins (for animal and fish feed)	0.3-1.5
Fine chemicals / food ingredients	10-50
Ingredients for pharma, cosmetics, high end nutraceuticals	150 and higher (> $1000/Kg for astaxanthin)

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Waterless Fracking

What is Hydraulic Fracturing

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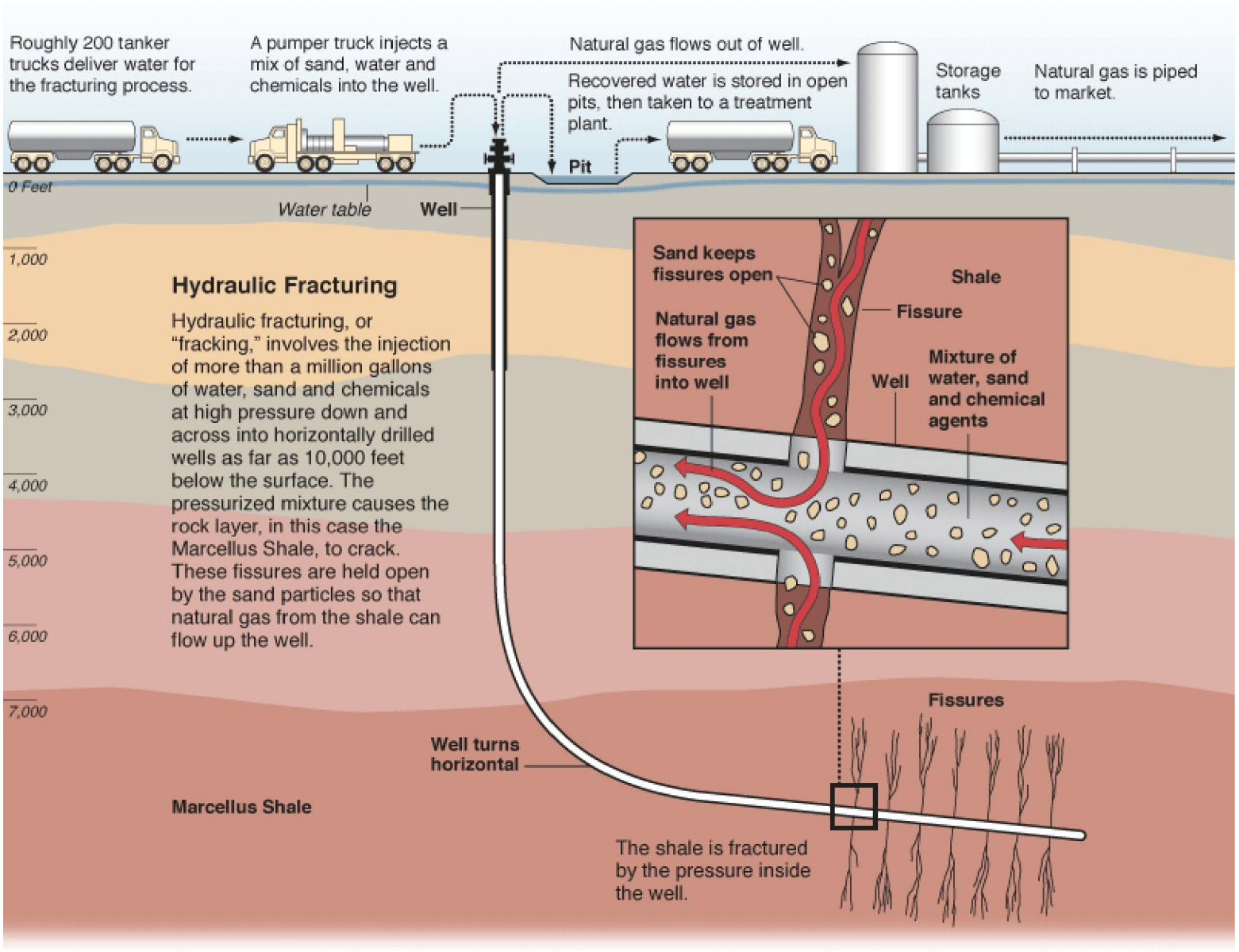

Water-Related Fracking Issues

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- Deeper horizontal shale wells can use anywhere from 2 to 10 million gallons of water to fracture a single well
- In 2010, the U.S. Environmental Protection Agency estimated that 70 to 140 billion gallons of water are used to fracture 35,000 wells in the United States each year. This is approximately the annual water consumption of 40 to 80 cities each with a population of 50,000
- The extraction of so much water for fracking has raised concerns about the ecological impacts to aquatic resources, as well as dewatering of drinking water aquifers
- It has been estimated that the transportation of two to five million gallons of water (fresh or waste water) requires 1,400 truck trips. Thus, not only does water used for hydraulic fracturing deplete fresh water supplies and impact aquatic habitat, the transportation of so much water also creates localized air quality, safety and road repair issues
- Wastewater pits also represent a major environmental issue

How Can CO_2 Help

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- The industry has sometimes used nitrogen and carbon dioxide (CO_2) in so-called “energized” or “foamed” frack fluids to reduce water usage
- Recent research has focused on the use of CO_2 to *completely eliminate water* used in fracking
- The CO_2 would be in a chilled form known as a “super-critical fluid” that is neither solid nor liquid
- Field trials have proved that it could produce more oil and natural gas by fracking with CO_2 instead of water, because CO_2 fracks occur at higher temperatures
- In conventional fracking, the frack water that stays in the formation can block the flow of hydrocarbon, therefore slowing down production and decreasing the amount it can produce over its lifetime. In contrast, using CO_2 allows the hydrocarbon to flow more freely and results in a better network of fractures
- CO_2 helps better oil sweep as it avoids “fingering”
- Trials with liquid CO_2 are showing very promising results

Fracking With CO_2 Research Opportunities

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- Detailed assessment of CO_2 fracking compared to water, especially from environment impact aspect
- Determining the right viscosity for the CO_2, in order that it can do the job that water does now
- Transporting CO_2, a compressible gas, in large quantities for use in frack wells that are far from pipelines
- Capture and separation of “back-produced” CO_2

Big CO_2 Research Opportunity

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Make CO_2 capture cheaper, especially for retrofit

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