



Water-Jet Oil Production Technology

A CANDIDATE FOR INNOVATIVE CRUDE PRODUCTION METHOD UNDER CALIFORNIA'S LCFS PROGRAM

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California Jet Oil, LLC was established by Marc Whitezell in 2014 to develop innovative technologies to improve the recovery of California's oil resources. Marc has over 15 years experience as a technical and operational expert in the California oil industry and holds multiple advanced degrees in engineering and business. Marc was raised in Bakersfield, CA and still lives there today with his wife and 4 children.

Water-Jet Oil Production

Reducing the carbon intensity of crude production

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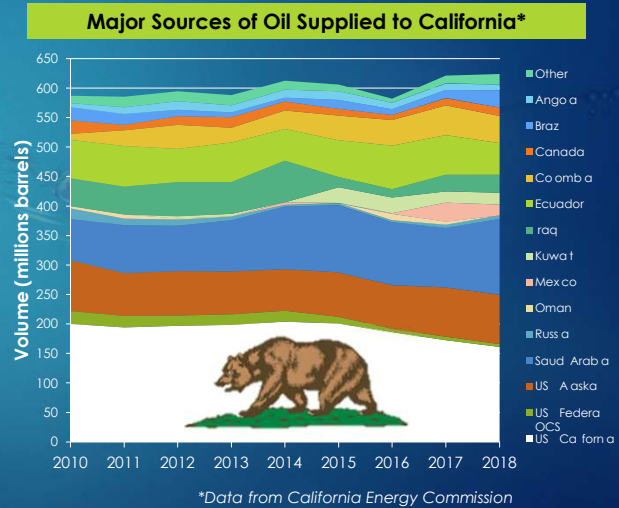
- ▶ Water jet oil production technology potentially provides a new way to reduce the carbon intensity of crude production, helping California achieve its emission goals.
- ▶ Technology was developed in the spirit of the state's LCFS program.
- ▶ Current LCFS regulations did not anticipate such innovative production methods.
- ▶ Rulemaking request is to include this technology as an eligible innovative crude production technique under CA's LCFS program.

Oil Remains a Large Part of Our Energy Mix

CA demand will continue for the foreseeable future

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- ▶ California's annual oil consumption increased by over 37 million barrels during the previous decade.
- ▶ At the same time, California's in state production has declined to only 25% of our demand.
- ▶ Developing innovative methods to reduce the carbon intensity of crude oil production is critical to helping California achieve its emission goals.



We import 75% of our oil from out of state to meet our needs. That is over 19 billion gallons of oil each year! That represents over \$20 billion per year that we send out of California to meet our oil needs (assumes current oil pricing of \$45/bbl).

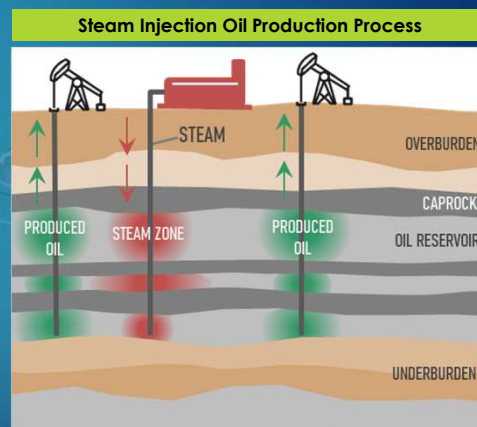
Source: <https://www.energy.ca.gov/data-reports/energy-almanac/californias-petroleum-market/oil-supply-sources-california-refineries>

Current Method: Steam Enhanced Oil Production

Steam injection is used to help increase oil production

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- ▶ Steam is injected into the reservoir to lower oil viscosity, allowing it to flow more easily to the wells.
- ▶ Steam is typically generated by burning natural gas.
- ▶ Typical steam to oil ratios: 3:1 to 10:1.
- ▶ Innovative methods recognized in current LCFS language only recognize renewable *thermal* techniques, but don't consider **non thermal** technologies.



Thermal oil recovery technology has been used for decades to improve recovery of oil from California's oil resources. Steam is injected into the rock, lowering the viscosity of the oil and allowing it to flow more easily to the wells where it is pumped to the surface. The steam used to support these oil recovery projects is typically generated using natural gas fired steam generators, and it typically takes 3-10 barrels of steam injected to produce one barrel of oil.

CARB's LCFS program currently recognizes solar steam and solar heat generation technologies as approved "innovative crude production methods," but doesn't consider non-thermal technologies.

Water-Jet Oil Production Technology

Non-fracking, low carbon intensity oil production technology

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4 Step Process

1

Drilling

- A normal oil well is drilled to the top of the targeted oil-bearing rock interval. Steel well casing is cemented in place across overburden.

2

Water-Jet Production

- Water-jet tool is lowered into the well and is used to mix water with the surrounding oil-bearing rock so that it can be transported to the surface through the tool.

3

Surface Separation

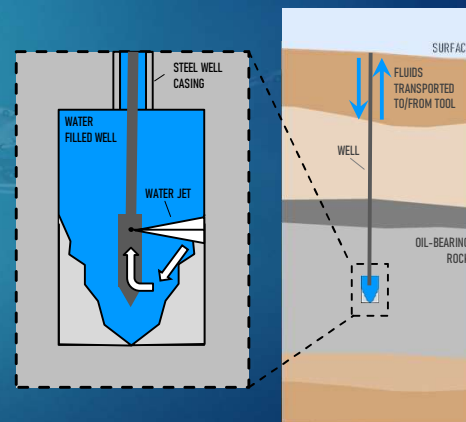
- At the surface, a highly efficient process is utilized to separate oil from the rock.

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Restoration

- Cleaned rock is recycled back in place, well is plugged, & surface restored.
- Water is recycled to be reused in the water-jet production process.

Water-Jet Production Process



Water-jet technology combines existing technologies in a new and innovative way to improve the recovery of California's oil deposits.

The process can be performed almost entirely using only electricity, eliminating most of the heat demand that traditional steam injection processes require, significantly reducing the carbon intensity of the oil production process.

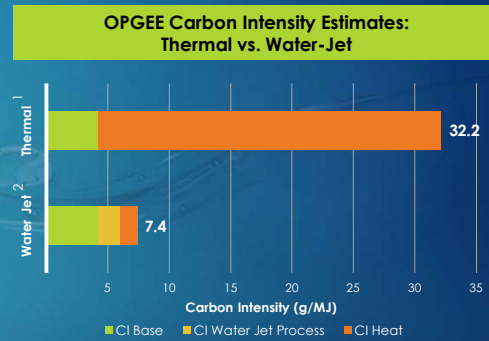
Notice that injection of steam is not necessary, nor do pumping units remain in place for years at the surface. Once oil is removed from the rock and the cleaned rock is returned downhole, the surface operation moves on. This means surface restoration occurs much sooner than in traditional oil producing fields.

Water-Jet Method Materially Lowers Emissions

Lower heat demand lowers carbon intensity

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- ▶ Compared to thermal oil recovery methods, water jet technology significantly lowers:
 - ▶ Carbon intensity: **77%**
 - ▶ Natural gas demand: **95%**
 - ▶ Criteria pollutants: **95%**
- ▶ For every 1,000 barrels of daily oil production replaced by water jet technology, **58,000 tonnes CO2e are saved annually.**^{1,2}
- ▶ Water jet carbon intensity is also **below all foreign imports.**



1. Thermal CI estimate assumes steam to oil ratio (SOR) 6. Typical thermal recovery process ranges in SOR from 3-10.
 2. Water jet CI estimate assumes use of waste heat in surface process.

The water-jet method significantly reduces the amount of heat needed to recover oil from CA's heavy-oil diatomite resources. Since natural gas is burned to generate heat for typical thermal oil recovery projects, water-jet technology allows a significant reduction in emissions--both GHG and criteria air pollutants.

Using existing steam injection techniques as the baseline, water-jet technology has the potential to reduce carbon intensity of crude production process by 77%, or 58,000 MT CO2e/yr for each 1,000 bopd replaced by the technology.

To put these emissions savings in context, converting one 20,000 barrels of oil a day thermal project to water-jet recovery, would result in an **emissions reduction 100X larger than the average existing innovative crude project.** Source:

<https://ww2.arb.ca.gov/resources/documents/approved-innovative-crude-oil-applications-under-lcfs>

Water-Jet Method Complies with All Regulatory and Environment Requirements

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Meets or exceeds all regulatory guidelines

- ▶ **Well permitting:** CalGEM
 - ▶ *The water jet process operates below standard reservoir pressures, therefore no special fracking or UIC permitting required.*
- ▶ **Ground water:** Regional water boards
 - ▶ *Water jet minimizes impact to ground water quality as no water is injected out into the formation, and all water is recycled and reused in the process.*
 - ▶ *In addition, no fresh water is required to support the water jet process.*
- ▶ **Air emissions:** Local air districts
 - ▶ *Besides reducing emissions by not burning natural gas to make steam, major processing components are run on electricity, further lowering emissions concerns.*
- ▶ **Surface work:** Local counties act as CEQA Lead Agency
 - ▶ *Water jet reduces surface use by significantly reducing the well life cycle from decades to days.*



Water-jet technology complies with all local and state regulatory guidelines. In fact, water-jet technology allows a significant reduction of environmental impacts.

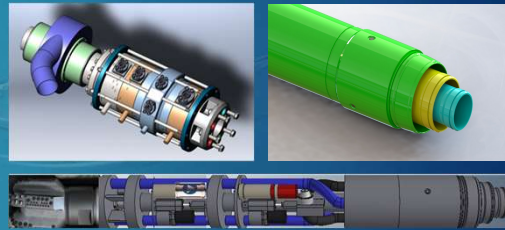
LCFS Incentives Lower CA's Crude Carbon Intensity

Water-Jet production replaces higher CI processes and imports

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- ▶ Significant initial capital investment required to construct, pilot, and operate water jet system and supporting equipment.
- ▶ Market conditions are not anticipated to support the economic application of water jet technology for the foreseeable future.
- ▶ LCFS incentives are critical to the development and operation of water jet technology to lower CA's crude carbon intensity.
- ▶ LCFS incentivizes the replacement of higher CI recovery processes with low CI water jet technology.

Water-Jet Equipment

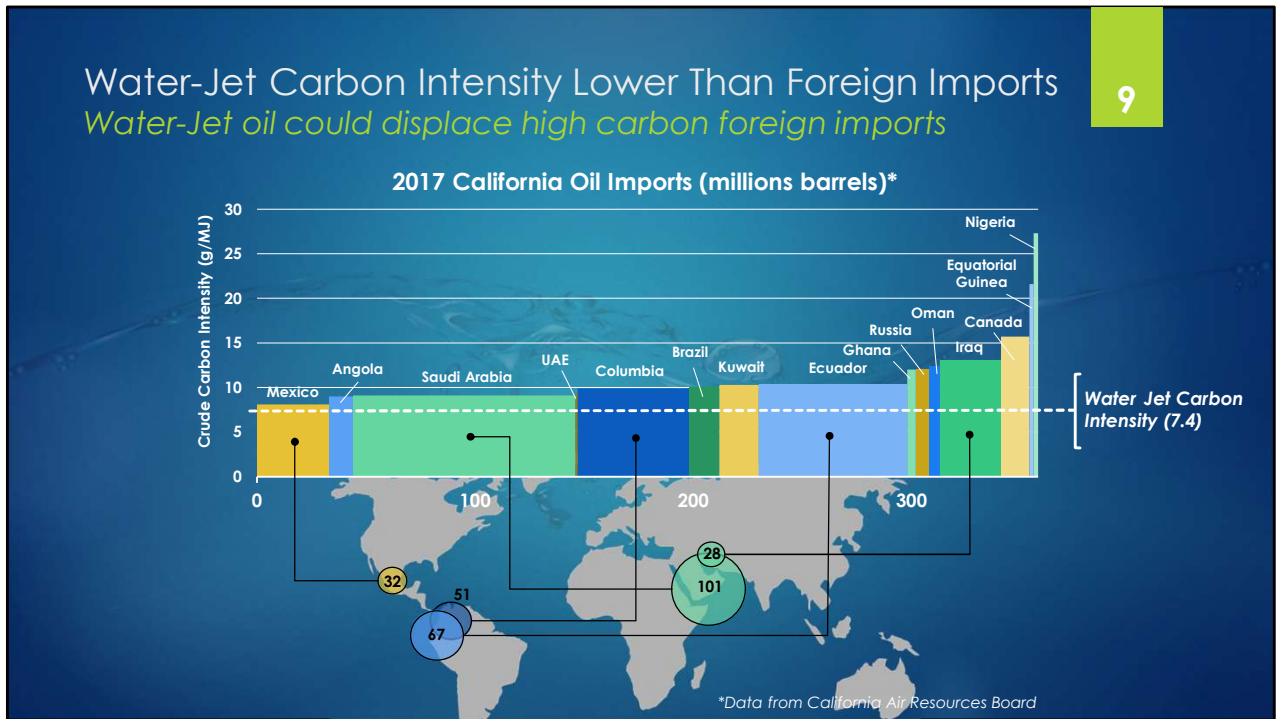


Development of a new technology to replace existing, higher carbon intensive techniques, requires a significant investment, and water-jet technology is no exception.

Market conditions are not anticipated to support economic application of water-jet technology for the foreseeable future. Qualification of water-jet technology as an Innovative Crude Production Method under the LCFS program would allow adoption of the technology to help lower California's crude oil carbon intensity.

Water-Jet Carbon Intensity Lower Than Foreign Imports

Water-Jet oil could displace high carbon foreign imports



California has a significant opportunity to displace higher carbon intensity crude imports with locally produced, low carbon-intensive, California oil using water-jet technology.

Summary

Reducing the carbon intensity of crude production in California

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- ▶ For the foreseeable future, oil remains an important part of Californian's every day lives.
- ▶ Californians only produce enough oil to meet 1/4 of our daily needs and import high carbon foreign crude to meet our growing needs.
- ▶ Water jet oil production poses a unique and truly innovative approach to producing California's oil deposits with a lower carbon footprint.
- ▶ Water jet oil production is a natural fit with the LCFS program and we propose that it be recognized in CARB's upcoming rulemaking.

Water-jet technology provides a way to meet CA's oil needs while reducing both carbon intensity and foreign crude oil imports.