APPLICATION TO THE EXECUTIVE OFFICER FOR LCFS CREDITS

FOR USING INNOVATIVE METHODS FOR CRUDE PRODUCTION

OR AMEND §95849(c)(1)(A)

CYCLIC STEAM REPLACEMENT

CLEAN SURFACTANT ENERGY (CSE) PROJECT

RENEWABLE AND BIODEGRADABLE SURFACTANT

Site:

Thermal Heavy Oil Fields, California

See what chemistry reducing viscosity looks like in the following video:

VIDEO

EXECUTIVE SUMMARY

Respectfully, to the Executive Officer:

We apply for approval of a groundbreaking innovation in crude oil production—chemistry that replaces steam emissions and lowers the carbon intensity in California's thermal enhanced oil recovery ("TEOR") operations. Awarding credits for the CRSE process aligns perfectly with the innovative crude oil production credit provisions of Cal. Code of Regulations, Section 95489(c)(1)(A).

TEOR relies on steam injection to reduce oil's viscosity, improve mobility, and increase production rates. However, as thermal heavy oil fields deplete, the Carbon Intensity (CI) rises in proportion to the Steam Oil Ratio (SOR). The CRSE process employs chemistry to reduce oil viscosity, improve mobility, and increase production rates of clean incremental oil. Cyclic steam is the business-as-usual method to produce incremental oil. This proposed chemistry innovation could eventually replace all steam injection while delivering similar volume of oil without the emissions of current TEOR methods.

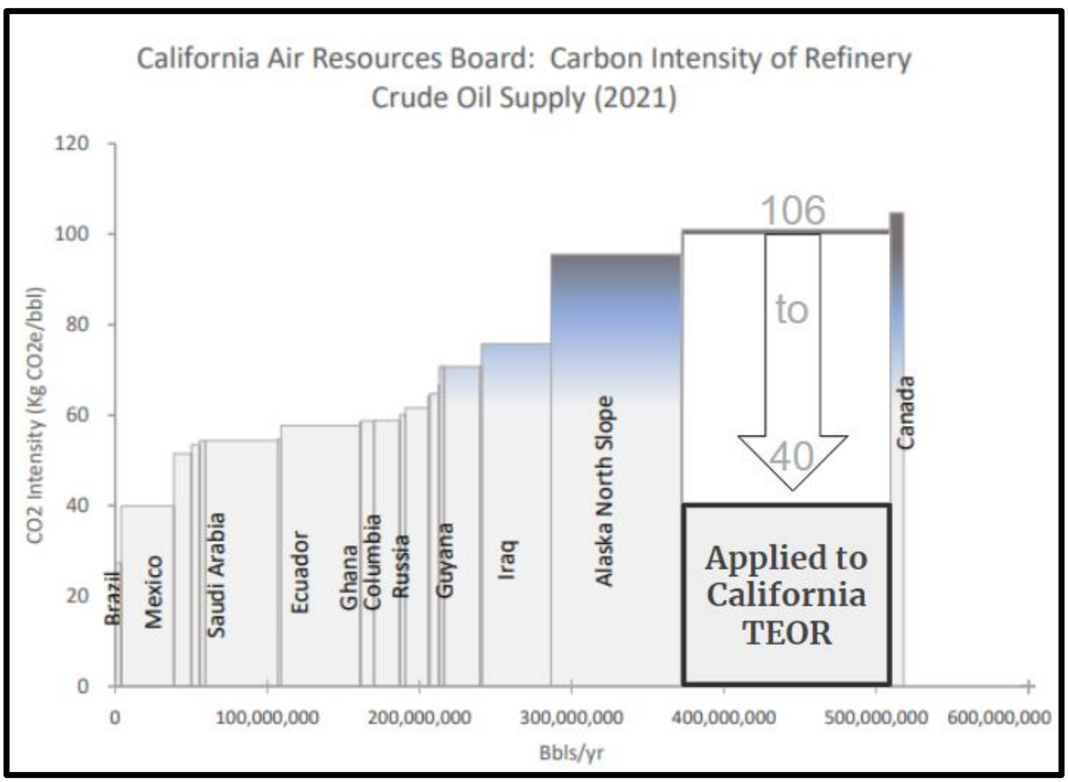
We are asking CARB to approve chemistry that replaces steam, as an innovative crude oil production method that is immediately scalable, sustainable and passes a cost-benefit analysis. The CRSE process enables Net Zero that is affordable, reliable and competitive. Decarbonizing goals require decarbonizing tools. Without approval, cyclic steam will continue polluting California's most vulnerable communities.

CARB can reasonably anticipate a reduction of over 30% in emissions associated with steam injection in TEOR projects. According to the OPGEE model, the carbon intensity of incremental oil from chemistry is 60-80% lower than steam.

Approving this method allows for chemistry to economically replace more than 2,600,000 tons of CO_2 emitted per year from California's TEOR operations.

Using current natural gas prices, $5.12 per mcf, steam costs across California's largest TEOR fields are $12.18 per barrel of oil. The cost of chemistry is $15.00 per barrel of oil. Approval results in a $5.61 per barrel of oil incentive to TEOR producers in the project area to replace steam with chemistry. This ultimately could push emission reductions even higher than 30%.

Approving this "Chemistry Replacing Steam" category under the Innovative Crude Oil Production Methods rewards producers for reducing and replacing steam injection, resulting in lower emissions while maintaining normal decline rates. The result is cleaner oil delivered to California refineries, contributing to a lower-carbon future for California—a meaningful win-win. Lowering California's crude oil carbon intensity by more than 60% from 106 to 40 kg CO2e / barrel of oil.



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APPLICATION TO THE EXECUTIVE OFFICER

I. Project Description: Chemistry Reduces Steam Emissions (CRSE).

The focus of this application is replacement of cyclic steam injection-- the method practiced in all California TEOR fields—with clean, safe chemistry to achieve the GHG reduction goals of this agency. The CRSE process enables CARB to play offense against climate change by rewarding oil companies for significant emission reductions.

The CRSE process is the stimulation of producing oil wells with a *nature-based,* pH neutral, renewable, and biodegradable proprietary formula surfactant that replaces steam. It is an advanced chemical and mechanical innovation that reduces emissions by 1) replacing steam, 2) lowering energy to lift oil, 3) reducing system friction, 4) improving downhole efficiency and 5) lowering heat required to separate heavy oil and water—resulting in a true low-carbon oil.

Unfortunately, since 2010, the CI of the largest heavy oil fields in California has increased 27%. Over the same period, only ten (10) Innovative Crude Method projects have been approved, collectively reducing no more than about 55,753 tons of CO2 per year (all solar electricity projects). In contrast, heavy oil-steam injection wells have injected 347.18 million barrels of steam through the first nine (9) months of 2023 to extract 52.18 million barrels of oil, giving a weighted SOR of 6.78 for the 9 largest TEOR fields in California, Table I.

Table I. 2023 Forecast of California's Largest Heavy Oil Field.

Field	Steam[1]	Oil[2]	SOR'23	County
Belridge, South	64,263,856	10,998,115	5.84	Kern
Coalinga	26,066,726	3,286,604	7.93	Kings
Cymric	48,083,958	8,979,218	5.36	Kern
Kern Front	14,840,285	1,615,521	9.19	Kern
Kern River	16,543,815	8,125,523	2.04	Kern
McKittrick	19,202,564	2,206,573	8.70	Kern
Midway Sunset	113,975,635	10,937,839	10.42	Kern
Poso Creek	18,580,392	2,190,442	8.48	Kern
San Ardo	25,623,744	2,860,026	8.96	Monterey
9 Months 2023	**347,180,975**	**51,199,861**	**6.78**	**9 Months 2023**
1 - CALGEM Well Type SC, SF, OG, UNK				
2 - CALGEM All Well Types				
Waterflood oil and potential steam classified under another well type				

CalGEM 2023 first 9 months steam/water volume injected, and oil produced. There is not a good way to separate steam from water injected and the associated oil. Attempted to be as conservative with the average SOR.

Source: California Department of Conservation: Well Production and Well Injection 2021-2023

Steam injection requires burning natural gas to heat fresh water that is injected underground into the heavy oil reservoirs. A barrel of steam emits approximately 23.677 kg CO2e. The SOR is the efficiency measurement of a field's response to steam. Since steam is directly related to emissions of burning natural gas, the SOR is directly related to oil's CI.

There are two types of steam injection: 1) continuous; and 2) cyclic. Continuous steam injection, as the name suggests, is continuous steam volume sent to an injector which provides support to a pattern of producing wells. Cyclic steam injection is specifically applied to producing wells to 'stimulate' oil production from the producers, measured as incremental oil. Cyclic steam is the most common practice for stimulating incremental oil.

Incremental oil is the increase in oil production from the 'stimulation' above a baseline assuming the stimulation never took place. When the stimulated production declines to the baseline, there is no longer incremental oil. The amount of cyclic steam injected determines the amount of incremental oil produced, and corelates directly to a TEOR field's SOR.

Industry widely accepts the SOR as the efficiency measurement of steam injection and emissions per barrel of oil produced. An example: A thermal field with a 10.0 SOR means 1,000 barrels of steam are injected, and 100 barrels of incremental oil are returned. *Vice versa*: 100 barrels of incremental oil produced with CRSE, in the 10 SOR field example, replaces 1,000 barrels of steam.

The CI of heavy oil cannot be reduced without a scalable innovation like CRSE that can be applied to every well to eliminate emissions caused by generating steam. The CI of the incremental oil from CRSE is 60-80% lower. Utilization at about 30%, projects carbon emission avoided will exceed 2,000,000 metric tons annually. (Please refer to Appendix C.)

CRSE chemistry reduces oil's viscosity without steam, avoiding emissions, reducing pollution, reducing freshwater usage and increasing oil production. This method changes both the numerator and the denominator of the CI calculation. The emissions avoided are proportionate to the SOR and the total volume of incremental oil.[1]

As the CRSE project eliminates cyclic steam *and* produces incremental oil, the combination reduces SOR and GHG in the petroleum supply chain. The result perfectly answers the call of CCR Section 95489(c)(1)(A). Thinking globally, but

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[1] OPGEE models Midway Sunset 10% incremental oil with and without steam, 29.33 to 3.54 gCO2/

acting locally, this agency can utilize CRSE to balance the need for emission reductions and energy security.

The CRSE project is the essence of energy efficiency, i.e., using less energy by eliminating cyclic steam to perform the same job (extraction of crude oil). In the process, CRSE cuts energy use; reduces air pollution; lessens freshwater usage; and poses no threat to water quality.

CRSE produces heavy oil with significantly less energy compared to steam, using chemistry, rather than heat, to reduce the Interfacial Tension (IFT) of oil in the formation.[2] This reduction eliminates the need for steam to lower oil viscosity. The product and process reduce CI from the baseline comparison by *far more* than the minimum of 0.10 gCO2e/MJ required by Cal. Code Regs. Title 17 § 95489.

CARB's 2030 CI target for the state's oil extraction industry will be achieved with a 45% adopted, this goal could be achieved in twenty-four (24) months.

The downhole placement of CRSE reduces friction in the artificial lifting and transportation process. Application of CRSE requires very limited energy inputs and results in near zero emissions. Using a limited equipment footprint, consisting of light duty trucks with a low- pressure pump, the CRSE is efficiently and safely placed. This equipment's footprint can be quickly scaled up across the region.

This project warrants rapid approval, first, because the innovative method can be easily scaled to impact every TEOR well that is, or will be, cyclic steamed. Second, this is the only reasonable solution to enable the oil industry to achieve

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MJ.

[2] Incremental oil results from combination of the following: 1. removing organic deposits; 2. destabilizing emulsions; 3. modifying completion and wellbore region to water-wet state; and 4. mobilizing contacted oil.

20% CI reduction by 2030 and beyond. Third, approval will create a clean oil demand, prompting further innovation in production of cleaner crude by reducing reliance on steam, lowering harmful emissions, reducing freshwater demand, while providing economic security for impacted communities of the San Joaquin Valley. Ultimately, it must be acknowledged that achieving decarbonizing *goals* requires decarbonizing *tools* like the CRSE process.

The CRSE advantage is akin to the avoided emissions associated with solar steam generation. The avoided emissions from replacing steam are based on the average steam quality, multiplied by the SOR, multiplied by the amount of incremental oil produced by the innovative crude production method.

Assuming 60% steam quality for our example above: 100 barrels of oil incremental, and 10 SOR, avoids 1,000 barrels of steam, the emissions avoided is 23,677 gCO2e/barrels of steam. This is equivalent to 23,677,000 gCO2e or 23.67 tons CO2e for 100 barrels of incremental oil.

This agency has mandated that the Low Carbon Fuel Standard is designed *to decrease the carbon intensity of California's transportation fuel pool and provide an increasing range of low carbon and renewable alternatives.* Companies should be motivated to innovate ways to decrease steam *and* find new ways to make cleaner incremental oil. By accomplishing both objectives, the CRSE process achieves the essential purpose of the LCFS program.

A. CRSE Reduces Drilling and Workover Tasks.

The CRSE process enables a win-win by reducing steam injection volumes, greenhouse gas emissions *and* the SOR of TEOR production. While GHG reduction is guaranteed, incremental production is equally certain. Ultimately, the need to drill more wells is reduced by recovery of incremental oil. CRSE contributes to a resilient clean energy future.

The benefits of CRSE over cyclic steam injection also include lower injection pressures on the tubulars in each well. There is no heat to cause thermal expansion which jeopardizes wellbore integrity. The CRSE process uses the hydrostatic pressure of the well to push fluids into the formation. CRSE can employ recycled produced water in the process, rather than fresh water.

B. Process of Applying Renewable and Biodegradable Surfactant in the Producing Zone to Replace Steam Injection Is New.

The CRSE formulation was first achieved in the last year. The chemistry of the plant-based surfactant is a unique trade secret. Field and lab testing has been ongoing.

GHG reduction coupled with incremental oil from a nature-based process is revolutionary because conventional industry wisdom has formulated an "either or" decision. The operator can *either* cut emissions *or* maintain production. *Until now*, the industry has resisted the possibility of *achieving both critical goals*.[3]

Heavy oil operators have learned if they reduce steam injection, oil production declines almost immediately. Following conventional wisdom, the operator will never be able to reduce CI values *without* the CRSE innovation. Too, CRSE is the most efficient means available to achieve the desired outcome: lower CI, delivering cleaner crude oil to California refineries.

[3] Recent oil prices prompted increases in cyclic steam injection that would have been avoided with CRSE in use.

II. Process Diagrams

The CRSE process requires access to the same annulus or tubing string found in all existing wells. The product is pumped under low pressure down the backside of the well and the hydrostatic head of the fluid column pushes CRSE into the reservoir. The precise mechanical means of delivery will vary slightly from well-to-well and field-by-field.

The CRSE process takes sixty (60) minutes on-site. The well is put into circulation for twenty-four (24) hours, then returned to production. CRSE can be applied throughout the remaining economic life of the TEOR well. Please refer generally to diagrams at Appendix A.

III. Map and Location

The list of fields and opt-in operators which have cyclic steam or steamflood type well codes according to CalGEM, is listed in Appendix B (California Heavy Oil Production).

IV. Estimate of LCFS Credits

The renewable and biodegradable characteristics of the CRSE product is part of the value proposition in this application. Please refer to the LCA for Product and Process at Appendix C.

The credit calculation for crude oil produced or transported using any other innovative method listed in section 95489(c)(1)(A) can by used to calculate credits generated and *could* employ the following formula:

$$Credits_{innov}(MT) = (Avoided_{emissions} \times SOR_{cyclic} \times V_{innov} - Emissions_{innov} \times T_{innov}) \times C$$

Figure 1. Suggested Chemistry Reduces Steam Credit Calculation

Where, $Credits_{Innov}$ (MT) is the amount of LCFS credits generated (a positive value), in metric tons, by the volume of a crude oil produced or transported using the innovative method and delivered to California refineries for processing.

$Avoided_{emissions}$ assuming displacement of steam produced using a natural gas fired once through steam generator are correlated with the steam quality as tabulated in section 95489(c)(1)(F).

SOR_{cyclic} is the fields previous year's SOR cyclic steam jobs.

V_{innov} is the volume, in barrels, of crude oil produced or transported using the innovative method and delivered to California refineries for processing. If the crude produced or transported using the innovative method and delivered to California refineries is part of a blend, then V_{innov} is the volume of blend delivered to California refineries times the volume fraction of crude within the blend that was produced or transported using the innovative method.

$Emissions_{innov}$ are the life cycle emissions for the CRSE product and process, with the units of $gCO2e/bo_{innov}$.

T_{innov} is the number of treatments performed contributing to V_{innov}.

Where, C is $10x^{-6}$ MT/gCO_2e conversion.

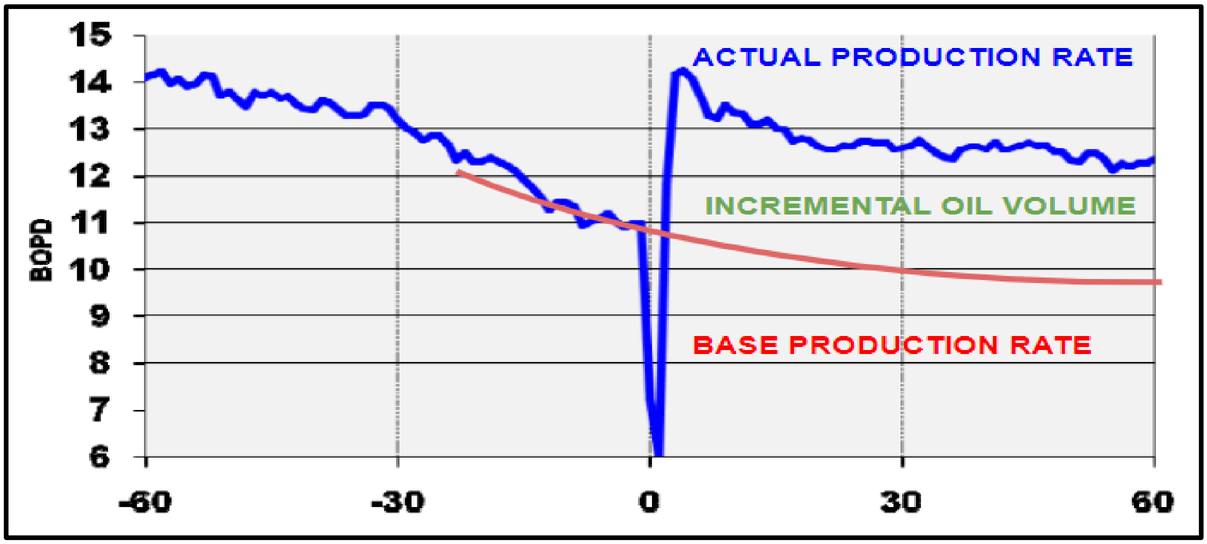


Figure 1. Volume Incremental Oil, V_{innov}

Incremental oil calculated from application of either cyclic steam or CRSE is actual production minus base production over a duration to determine volume. This is an example of a normalized plot over time, left is -60 days before job performed at time 0, to 60 days after job performed. This is an example of how incremental oil volume can be calculated for both cyclic steam jobs and CRSE.

V_{innov} is the volume of incremental crude oil produced using this method. This is calculated on a well-by-well basis as the difference between a forecasted base production and actual production. The difference between actual and base production equals positive incremental oil over a duration of time. The time that incremental oil becomes negative, or another intervention is initiated, actual production falls below the forecasted base production, or until another incremental oil intervention is initiated.

V. Opt-in Producers

The Opt-in Producers include TEOR operators presently using heat produced by cyclic steam to reduce viscosity of crude oil within the producing zone (Table III). The geographic location of the target fields is Table IV.

Table III. Opt-in Producers Steam Well Codes

OPT-IN OPERATOR LIST		
Aera Energy LLC	E&B Natural Resources Management Corp	Pacific Coast Energy Company LP
Almond Crest Oil LLC	Gray Development Co. LLC	Paris Valley Petroleum
Armstrong Petroleum Corp	Hathaway LLC	Peak Operator LLC
Asphalta LLC	Holmes Western Oil Corporation	Santa Maria Energy, LLC
Berry Petroleum Company, LLC	Hunter Endison Oil Development Limited Partnership	Seneca Resources Company, LLC
C&M Oil Co. & Investments	HVI Cat Canyon, Inc.	Sentienl Peak Resources California LLC
California Resources Elk Hills, LLC	Jaco Production Company	Shadow Wolf Energy, LLC
CalNRG Operating, LLC	Kern River Holdings II, LLC	Standard Oil Company LLC
Chevron U.S.A. Inc.	Macpherson Operating Company, L.P.	Tidelands Oil Production Co.
CMO, Inc.	Naftex Operating Company	TRC Operating Company, Inc.
Crimson Resources Management Corp	NewBridge Resources, LLC	Vaquero Energy, Inc.

CalGEM operators own well type of cyclic steam, CS or steamflood, SF.

Table IV. Fields with Steam Injection Reported

FIELDS		
Antelop Hills	Elk Hills	Newport, West
Arroyo Grande	Huntington Beach	Orcutt
Asphalto	Jasmin	Oxnard
Belridge, North	Kern Front	Paris Valley
Belridge, South	Kern River	Placerita
Cat Canyon	Lost Hills	Poso Creek
Chico-Martinez	Lost Hills, NW	Round Mountain
Coalinga	Lynch Canyon	San Ardo
Cymric	McKittrick	Wilmington
Edison	Midway-Sunset	
Edison, NE	Mount Poso	

CalGEM operators own well type of cyclic steam, CS or steamflood, SF.

The CRSE process is the only scalable potential for TEOR extraction companies to achieve a 20% CI reduction by 2030. It requires producers to adopt and scale CRSE, or similar advancements if they become available, to replace 45% of steam injection. Please refer to LCFS Credit Calculation at Appendix D.

The need for this process is made urgent in the context of a climate crisis by the deleterious trend of increasing steam injection *and* increasing SOR. Without approval of the CRSE application, oil companies will continue to inject more steam into the ground, causing more dangerous emissions, in pursuit of the remaining economic barrels of oil. CRSE is an immediate opportunity to reverse this trend.

Table V represents nine (9) months of data projected over twelve (12) months with a forecasted 7.80% increase of steam and emissions while oil decline rates accelerate. This relates to injecting more steam into the ground, more deadly emissions into the air and a higher decline rate. Most troublingly, it results in more emissions and less oil. This trend will continue until an economic alternative appears.

Table V: Three Year Steam Oil Change

YEAR	STEAM[1] bbls	OIL[2] bbls	% CHANGE	
2021	468,490,097	82,910,163	**Steam%**	**Oil %**
2022	453,476,668	76,921,783	-3.20%	-7.22%
Assume 22 to 23	438,944,366	71,365,927	-3.20%	-7.22%
Forecast 2023	474,332,861	69,578,400	4.60%	-9.55%
23 Fore-Assume	**35,388,496**	**(1,787,527)**	**7.80%**	**-2.32%**
1 - CALGEM Well Type SC, SF, OG, UNK - may not capture all steam				
2 - CALGEM All Well Types- includes waterflood oils.				

Table V is California's top 9 TEOR fields trend. Assume 22 to 23 is 'nothing changes from 22 to 23 scenario, could expect these numbers. Forecast 2023 is 9 months actual forecasted for 12 months.

23 Fore – Assume is the difference between Forecast 2023 minus Assume 22 to 23.

This trend will likely continue with depleted reservoirs.

Forecasting the nine (9) largest TEOR fields, producers are on track to inject 35 million more barrels of steam, nearly 828,000 tons of CO_2, and produce 1,700,000 barrels of oil less. More emissions that are uneconomical. This results in higher SORs and higher CIs. Expect more of this without CRSE. While employing CRSE would have improved those numbers significantly.

VI. CRSE and Confidential Business Information

The formulation of CRSE used downhole in any well will vary slightly to address specific geochemistry and downhole conditions. The principal product delivered by the project is a renewable and biodegradable surfactant formulated as a trade secret under proprietary terms and conditions.

VII. Reporting and Recordkeeping

Opt-in Producers will provide records of production and steam inputs from the normal course of operations to establish the historical SOR baseline. The same details are reported monthly to CalGEM. The incremental oil will be based on a well-by-well decline rate, as if the stimulation hadn't occurred. The incremental oil will be calculated above the baseline until production drops below the baseline.

Reporting will ensure compliance with robust standards of additionality, quantification, and permanence. Records will facilitate third-party audit of emissions claims and enable all interested parties to track and audit credits. Monitoring, reporting, and verification ensure that the CRSE project performs as predicted by project design.

VIII. CRSE Process Meets Standard Interpretation of CARB Regulations.

This application relates to a new innovative chemical method to reduce emissions and decarbonize oil production, incorporating Cal. Code of Regulations, Title 17, Section 95489(c)(1)(A), which provides, in pertinent part:

> For the purpose of this section, an innovative method means crude production or transport using one or more of the following technologies:

1. Solar steam generation (generated steam of 45 percent quality or greater). Steam must be used onsite at the crude oil production or transport facilities.

2. Carbon capture and sequestration (CCS). Carbon capture must take place onsite at the crude oil production or transport facilities.

3. Solar or wind electricity generation. To qualify for the credit, electricity must be produced and consumed onsite or be provided directly to the crude oil production or transport facilities from a third-party generator and not through a utility owned transmission or distribution network. Energy storage may be used to increase the quantity of electricity supplied to crude oil production or transport facilities from intermittent solar and wind electricity generation sources.

4. Solar heat generation including, but not limited to, boiler water preheating and solar steam generation with a steam quality of less than 45 percent. Heat must be used onsite at the crude oil production or transport facilities.

5. Renewable natural gas (RNG) or biogas energy. RNG or biogas must be physically supplied directly to the crude oil production or transport facilities.

Id.

The regulation is an open invitation to innovate the production of oil for one purpose: to reduce GHG emissions. Because the process proposed serves that purpose at scale, CRSE justifies *chemical reduction of viscosity* as a new category of innovative production method to eliminate steam *and* reduce emission of greenhouse gases.

Moreover, the innovative methods which have been previously approved, arguably encompass the functional advantages of CRSE and should justify approval of this application. Providing the same energy savings and emission reductions by innovative chemistry may prompt approval of this application without adding to the enumerated methods.

A. Reducing oil viscosity with a renewable product satisfies Method No. 1.

The CRSE process is a lower carbon alternative to solar steam generation whether viewed as a substitute or a perfect complement to steam by reducing oil viscosity. In direct competition, CRSE produces higher emission reductions than can be achieved by production from solar steam alone.

B. Sequestering carbon captured in CRSE satisfies Method No. 2.

The product is plant-based, absorbing carbon as it grows. By injecting the high carbon material into a geologic formation, the project sequesters carbon at every wellbore stimulation.

C. Renewable Product Facilitating Production Satisfies Method Nos. 3-5.

Downhole delivery of CRSE, a renewable and biodegradable product, to produce incremental oil is the functional equivalent of providing renewable energy for use in the production facility. It is simply an alternative tool for decarbonizing oil production.

D. Scalability Allows CRSE to Achieve High Volume Emission Reductions.

Oil and gas extraction have always confronted a declining denominator of the CI calculation. In heavy oil, reducing the emissions (numerator) as oil production (denominator) declines, still increases CI. Increasing oil production (denominator) while reducing emissions, is the only available means, given the constraints of technology and economics, to reduce CI of TEOR operations.

All current CARB innovative production methods focus on limited-scale emission reductions. None of these approved methods increase oil production.

None of them reduce operating costs. There is no economic incentive for the oil and gas industry to change, until they see a way to reduce emissions and extract more oil, in a truly scalable way. CRSE is that opportunity.

Replacing the business-as-usual method with the CRSE process delivering 60-80% lower emissions is the urgently needed answer. This innovation for the oil industry will spark new opportunities to replace high CI activities with lower carbon alternatives to achieve the desired outcome for all stakeholders.

CONCLUSION

Considering the urgent need to reduce emissions associated with production of oil in one of the most productive regions of the United States, the opportunity to cut emissions *and* maintain normal production decline rates justifies the expedited approval of this application. By reducing the amount of steam injected and complementing other methods to mitigate emissions, the applicant presents a rare win-win opportunity for this agency and the oil industry. We respectfully request your expedited approval of this innovative crude oil production method, recognizing its potential to revolutionize the industry and create a positive impact on both the environment and the economy.

Dated: December 15, 2023

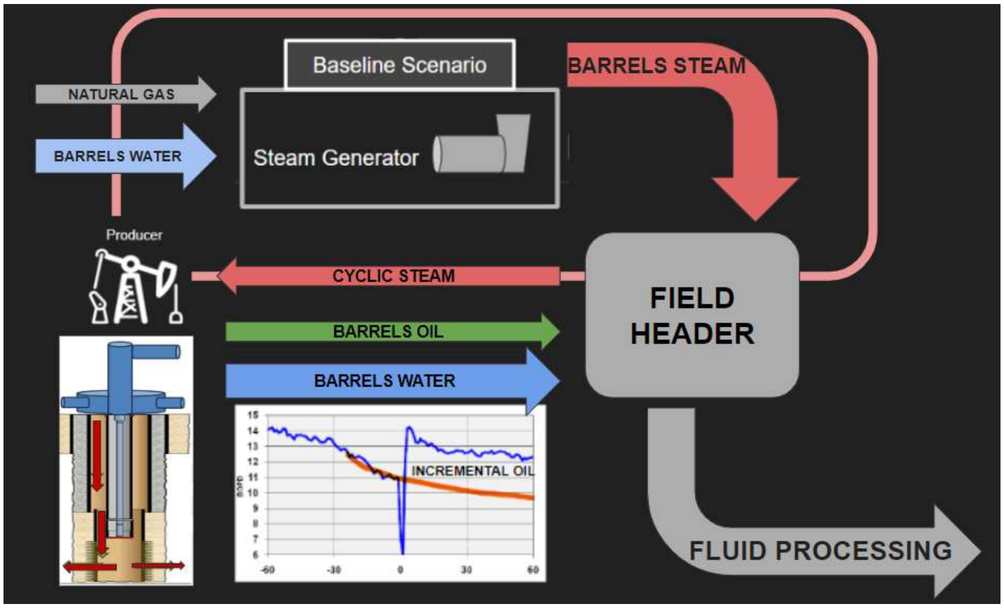
Respectfully Submitted,

Jesse Holman, CEO
Senergy, Inc.

LIST OF APPENDICES

APPENDIX A. Process Diagrams

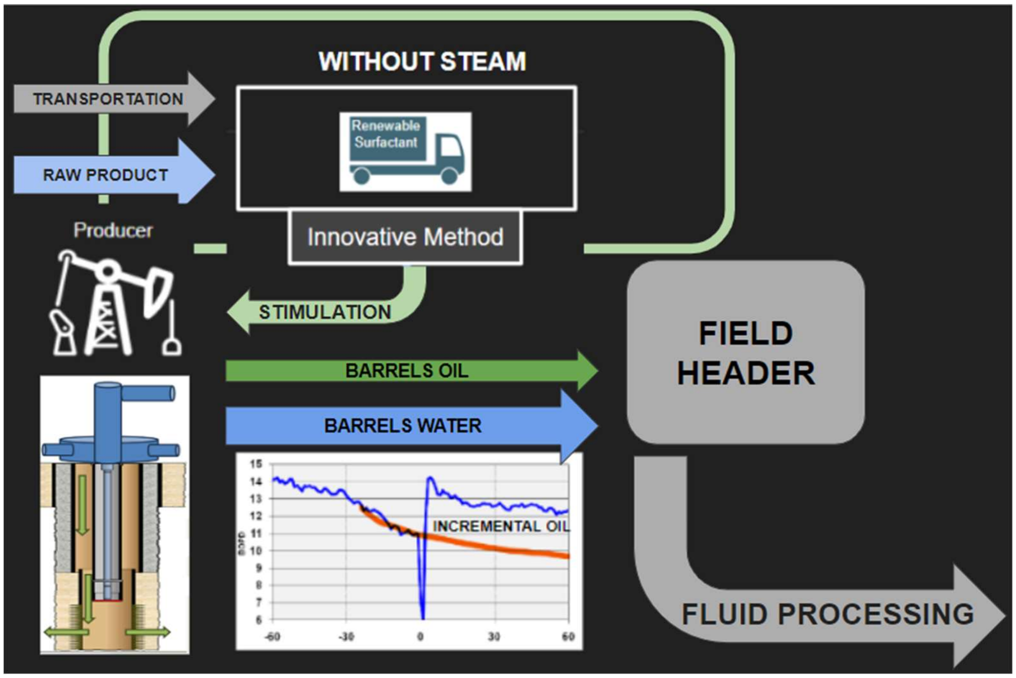
Baseline Scenario: Cyclic Steam



Cyclic steam used on producers for enhancing oil production.

A cyclic steam job is used to stimulate incremental oil in producer wells, the pumping unit is stopped, steam is diverted from the field header, down the flowline, into the backside annulus of the well delivering a predetermined volume of steam for a period of time. The steam is turned off and the well is put back on production. The steam volume injected must be recovered which contributes additional energy above the emissions injected. The well is back producing oil and water.

Innovative Method: CRSE replaces Cyclic Steam



Stimulation product assists with chemistry at fluid processing plant, there is no additional waste streams created.

Clean Surfactant Energy stimulation is a renewable and biodegradable stimulation fluid. The well is shut down and isolated. Stimulation fluid is injected using low pressure centrifuge pump and reused lease water, approximately 25 barrels of water to hydrostatically push stimulation fluid into the formation. The well is then put in a 24 hour circulation period before being returned to production. The treatment process requires less than 20 minutes of pump time before moving on to the next well. The stimulation fluid is of similar components of chemistries injected at the fluid processing facility and improves the existing separation streams without creating any additional waste streams.

What does this look like in the field?

- A – Chemical Totes
- B – Water Source
- C – Manifolded Suction Transfer Hoses
- D – C-Pump (130 psi/4 bpm)
- E – Pressure Hose (note check valve at E2)

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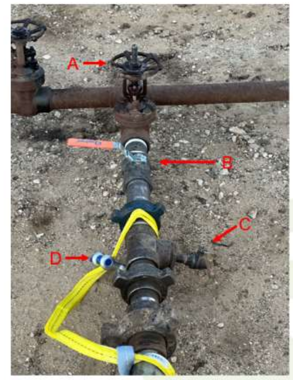
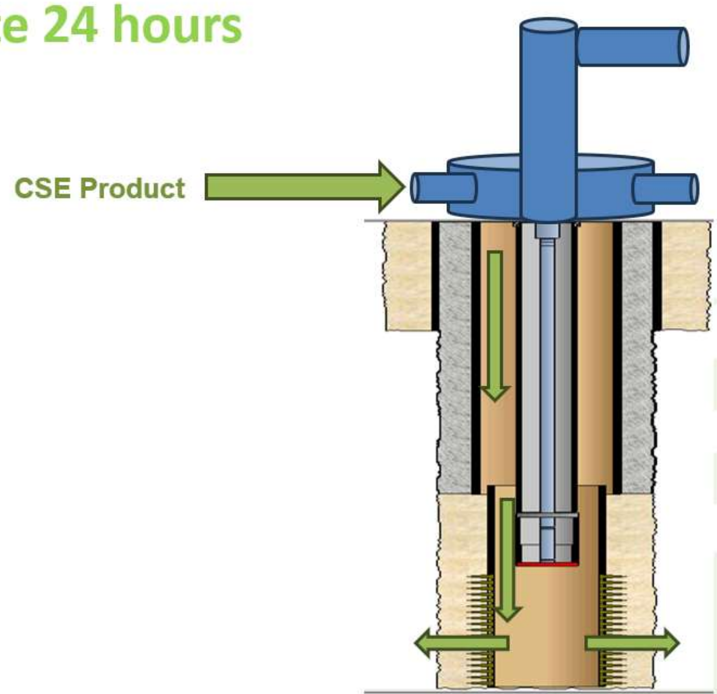
Connected to Wells Flow Line

- A – Operator Valve
- B – Isolation Valve
- C – Bleeder
- D – Hose Hobble



Fluid Pumped Down Backside

Circulate 24 hours



APPENDIX B. List of Thermal Injection Fields and Operators.

Table I. Opt-in Producers Steam Well Codes

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Aera Energy LLC	E&B Natural Resources Management Corp	Pacific Coast Energy Company LP
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Berry Petroleum Company, LLC	Hunter Endison Oil Development Limited Partnership	Seneca Resources Company, LLC
C&M Oil Co. & Investments	HVI Cat Canyon, Inc.	Sentienl Peak Resources California LLC
California Resources Elk Hills, LLC	Jaco Production Company	Shadow Wolf Energy, LLC
CalNRG Operating, LLC	Kern River Holdings II, LLC	Standard Oil Company LLC
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Table II. Fields with Steam Well Codes

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Cat Canyon	Lost Hills	Poso Creek
Chico-Martinez	Lost Hills, NW	Round Mountain
Coalinga	Lynch Canyon	San Ardo
Cymric	McKittrick	Wilmington
Edison	Midway-Sunset	
Edison, NE	Mount Poso	

APPENDIX C. LCFS Credit Calculation

The credit calculation for crude oil produced or transported using any other innovative method listed in section 95489(c)(1)(A) can by used to calculate credits generated and *could* employ the following formula:

$$Credits_{innov}(MT) = (Avoided_{emissions} \times SOR_{cyclic} \times V_{innov} - Emissions_{innov} \times T_{innov}) \times C$$

Figure 1. Suggested Chemistry Reduces Steam Credit Calculation

Where, $Credits_{Innov}$ (MT) is the amount of LCFS credits generated (a positive value), in metric tons, by the volume of a crude oil produced or transported using the innovative method and delivered to California refineries for processing.

$Avoided_{emissions}$ assuming displacement of steam produced using a natural gas fired once through steam generator are correlated with the steam quality as tabulated in section 95489(c)(1)(F).

SOR_{cyclic} is the fields previous year's SOR cyclic steam jobs.

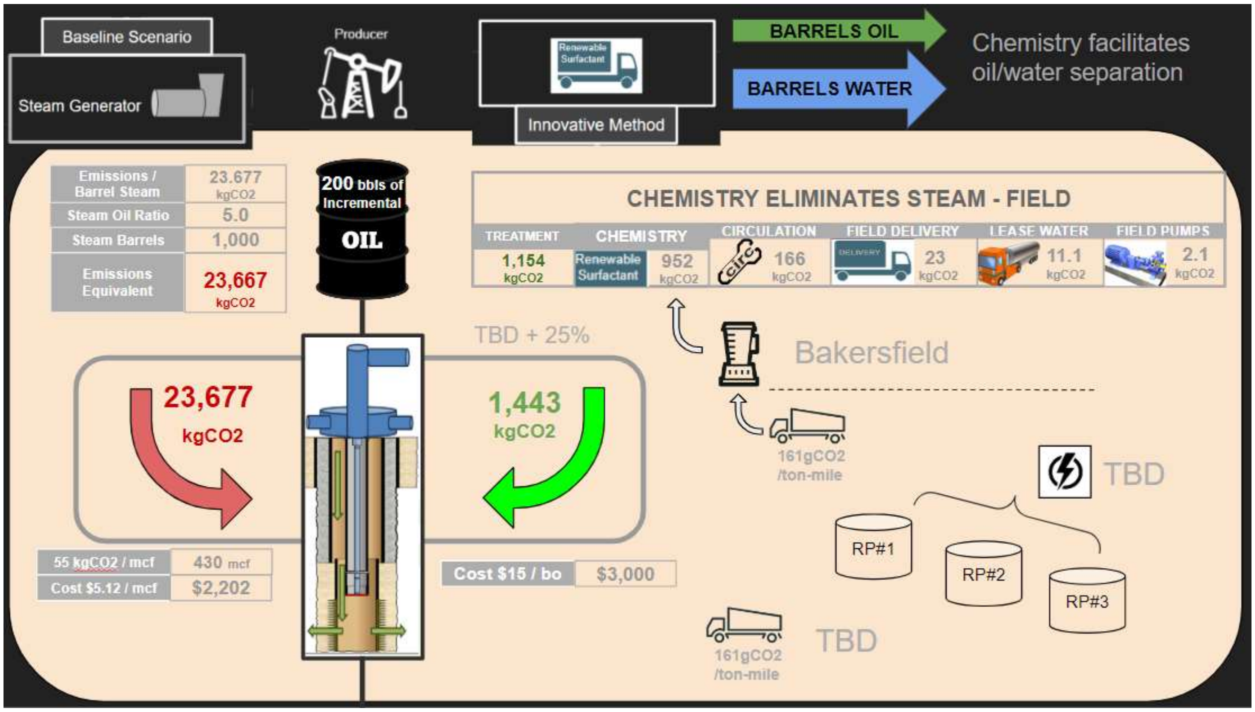
V_{innov} is the volume, in barrels, of crude oil produced or transported using the innovative method and delivered to California refineries for processing. If the crude produced or transported using the innovative method and delivered to California refineries is part of a blend, then V_{innov} is the volume of blend delivered to California refineries times the volume fraction of crude within the blend that was produced or transported using the innovative method.

$Emissions_{innov}$ are the life cycle emissions for the CRSE product and process, with the units of $gCO2e/bo_{innov}$.

T_{innov} is the number of treatments performed contributing to V_{innov}.

Where, C is $10x^{-6}$ MT/gCO_2e conversion.

APPENDIX D. LCA for Product and Process



Lifecycle analysis of 200 barrels of oil, cyclic steam (baseline) SOR of 5 and Chemistry Reduce Steam (innovation).

The distance the raw products travel, and the blending electricity are currently unknown. We have added a 25% buffer for these emissions.

Source:

Vegetable Oil: https://www.epa.gov/sites/default/files/2015-07/documents/emission-factors_2014.pdf

Freight: Transportation value of 161 gCO2/ton-mile.

Steam Emissions from CARB.

Steam quality	*Avoided emissions (gCO_2e/bbl solar steam)*
95% and above	34,875
85% to <95%	30,443
75% to <85%	28,188
65% to <75%	25,932
55% to <65%	23,677
45% to <55%	21,421

APPENDIX E: Reporting and Record Keeping

Oil and steam volumes are reported and recorded to CalGEM agency. The additional record keeping required is the incremental oil volume using CSE. This requires a forecasted baseline production rate as if the stimulation didn't take place. Incremental oil is the difference between actual production post stimulation and the forecasted baseline until actual production falls below the baseline. This volume of incremental oil will be used to determine the credits available.

Therefore, records for incremental oil volume will vary well. The overall steam oil ratio and carbon intensity of the field will decline over time in accordance with the summation of all treatments that produce incremental oil.

APPENDIX F: Summary of Innovative Method Applications

SUMMARY OF INNOVATIVE METHOD APPLICATION

A. CRSE Delivers Emission Reductions *Beyond* Elimination of Steam in California.

1. Reduce lifting energy required in current levels of oil production.
2. Reduce maintenance demands for tubulars in existing oil wells.
3. Reduce drilling of new wells to bolster oil production.
4. Lower carbon emissions in production of heavy oil imported to California.
5. Reduce fuel consumed to transport imported crude to California refineries.
6. Reduces emissions in water flood production fields worldwide.
7. Increases efficiency of oil sand production in Alberta.
8. Reduces waste and downtime in aging refineries.
9. Encourages lower-carbon fuel production.
10. Sequesters carbon in geologic storage.

B. CRSE Delivers Advantages *Beyond* Decarbonization.

1. Reduce freshwater usage in oil and gas operations.
2. Increase recycling of produced water.
3. Efficient water polishing on-site.
4. Eliminate synthetic surfactants.
5. Cleanup facilities and sites.

C. CRSE Chemical Innovation Reduces Emissions *Beyond* the Oil Industry.

1. Firefighting:
   a) Reducing surface tension of water decreases evaporation before water reaches fuel.
   b) Reducing surface tension of water increases uptake on contact with fuel.
   c) Both effects increase firefighting efficiency at any scale.
   d) Efficiency reduces wildfire emissions.
   e) Efficiency saves water.
   f) Eliminates PFOAs.
2. Agriculture:
   a) Reducing surface tension of water increases plant uptake of moisture, reducing demand for water *and* improving yield.
   b) Reducing surface tension of water increases plant uptake of nutrients, reducing use of NPK fertilizer that contaminates water.
3. Environmental Remediation:
   a) Reducing surface tension of water improves removal of volatile organic compounds in soil.
   b) Reducing surface tension of water improves removal of oil spill contamination.
4. Cement Production:
   a) Reducing surface tension of water allows additives to reduce weight while increasing strength.

    b) Decreasing volume of cement production reduces carbon emissions.
5. Desalinization:
    a) Reducing surface tension of water improves efficiency of reverse osmosis.
    b) Cleaning RO filters prolongs the service life of the filter material.

D. Approving CRSE Application Puts a Carrot Before the Oil Industry Horse.

1. Increasing stakeholder expectations raise incentives for enterprise-level decarbonization.
2. Emerging laws and evolving regulations make decarbonization a C-suite priority.
3. Leaders will recognize competitive efficiency to seize growth opportunities.
4. Every measurable carbon reduction is progress to be encouraged.

E. Application Justifies Expeditious Approval of New Innovative Method.

1. Better to decarbonize than await a perfect solution.
2. Uncertainty should not create inertia.
3. CARB should lead the field.

F. CRSE Reduces More GHG Emissions than Currently Approved Methods Combined.

1. Section 95489(c)(1)(A) lists five (5) technologies approved as innovative methods.
2. The five (5) approved methods reduce emissions from generating steam.
3. CRSE eliminates steam generation altogether.