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Technical Memorandum on Lifecycle Emissions of Oil & Gas Extraction in the City of Long Beach

AECOM prepared this Memorandum (memo) to help the City of Long Beach understand lifecycle emissions associated with oil and gas extraction operations occurring within the city boundary. This analysis can provide a more holistic view of the City's contribution to global greenhouse gas (GHG) emissions, and complements the previous analysis of the city's GHG emissions provided through the more traditional production- and consumption-based inventories.

The memo is organized into 6 sections that address the following goals:

1. To understand the GHG footprint of gas and oil operations in Long Beach,
2. To understand how the carbon intensity of these operations in Long Beach compares with oil extraction elsewhere in California and internationally,
3. To give an overview of what happens to the oil and gas that is extracted in Long Beach,
4. To describe how oil and gas operations in Long Beach are regulated by the State,
5. To provide descriptions of best practices in technological interventions to minimize lifecycle emissions from gas and oil operations, and
6. To give a high-level overview of recommendations to transition away from gas and oil activity over time.

This memo provides a broad stroke analysis of global oil intensity and may not consider all local factors. The memo does not include a cost or cost effectiveness analysis, quantification of the potential lifecycle GHG reductions, or an assessment of the recommendations' impact on the city's oil and gas economy (e.g., revenue, employment).

Executive Summary

In 2015, 13.3 million barrels of crude oil and 5.1 million Mcf of natural gas were extracted in Long Beach. The lifecycle emissions resulting from this energy production total 8.3 million metric tons of carbon dioxide equivalent (MT CO_2e), which is 2.7 times greater than the city's 2015 production-based GHG emissions inventory.[1] The city's oil and gas lifecycle emissions were estimated based on an upstream emissions factor from the California Air Resources Board (CARB) specific to the Long Beach oil field, and midstream and downstream emissions factors from the Oil Climate Index (OCI) for a proxy oil field (California Wilmington) in lieu of a Long Beach-specific analysis, which was not readily available and could not be produced in the timeframe of this analysis to inform the draft CAAP. Based on the resulting lifecycle emissions factor, the total carbon intensity of oil extracted in Long Beach is the 14th highest out of 75 global oils surveyed in the OCI.

Approximately 96% of the city's oil and gas lifecycle emissions are attributed to oil, with the remaining 4% resulting from natural gas. It is estimated that 100% of natural gas extracted in Long Beach is consumed in the community, and that 100% of the oil extracted in Long Beach is consumed within California. Of the total oil and gas lifecycle emissions, 76% occur downstream (i.e., transport to consumers and end use of

[1] The City's production-based inventory, sometimes referred to as a scope-based inventory, was developed to be consistent with the Basic level requirements for a community inventory as outlined in the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC)

fuel), 14% occur midstream (i.e., oil refining), and 5% occur upstream (i.e., extraction); the remaining 4% are lifecycle natural gas emissions. Based on the OCI information for the Wilmington oil field, this analysis also assumes that the refining of Long Beach oil results in the creation of petcoke as a byproduct, which is likely exported for combustion outside of the United States because it is too dirty to be used in the United States. This byproduct contributes importantly to downstream emissions from Long Beach oil.

Understanding the lifecycle emissions sources help to define the City's opportunities for meaningful intervention. Upstream emissions occur at the oil fields within the city boundary. The City issues well permits for petroleum operations, and has relatively more direct control over these emissions. Potential opportunities to reduce upstream emissions primarily include energy efficiency improvements in the extraction process and increased leak monitoring and detection. Oil refining occurs outside the City's jurisdiction, where opportunities to reduce midstream emissions are limited to advocacy efforts for more stringent requirements from CARB, the Southern California Air Quality Management District, or other relevant permitting entities. Oil extracted in Long Beach is refined into various end products, which are consumed inside and outside the city boundary. Through its Climate Action and Adaptation Plan (CAAP), the City is pursuing actions that would reduce local consumption of fossil fuels from building energy efficiency improvements, reduced vehicular travel, and expansion of electric vehicle technology. As with the midstream emissions, the City's ability to influence use of Long Beach oil products outside of the city is primarily limited to advocacy for greater local action in those jurisdictions to limit fossil fuel use or for more stringent regulation (e.g., state, federal) of fossil fuel consuming uses (e.g., vehicle efficiency standards).

The City's long-term strategy to address oil and gas lifecycle emissions should be multi-pronged and include a goal to replace fossil fuel consumption in Long Beach with clean electricity and other renewable energy sources, support efforts to minimize global demand for oil and gas resources, phase-out local oil and gas extraction, and invest in carbon capture technology.

1. Summary of Oil and Gas Footprint

AECOM estimated the lifecycle footprint of oil and gas produced in Long Beach. Based on guidance from staff at CARB, this analysis combined information from OCI and the Low Carbon Fuel Standard (LCFS) Regulation to develop a lifecycle emissions factor for crude oil that approximates emissions for the Long Beach oil fields. Additional information was collected to estimate emissions from the production and use of natural gas occurring as a byproduct of oil production. The following sections describe these various inputs before presenting the lifecycle emissions estimates.

Emissions Factors

OIL-CLIMATE INDEX

OCI is an analytic tool that estimates the total lifecycle GHG emissions of individual oils and compares them among a global sample pool of 75 different oil fields. The lifecycle emissions include upstream extraction, midstream refining, and downstream end use. The database "was developed to alert public and private stakeholders to the full array of oils' climate impacts from various perspectives",[2] and can support a more holistic understanding of what public policies can address oil-related emissions.

OCI uses three different models to develop its emissions factors:

1. Oil Production Greenhouse Gas Emissions Estimator (OPGEE) for upstream production data
2. Petroleum Refinery Life-Cycle Inventory Model (PRELIM) for midstream refining data

[2] Oil-Climate Index. Available: <https://oci.carnegieendowment.org/#about>

3. Oil Products Emission Module (OPEM) for calculating GHG emissions associated with transporting petroleum products from the refinery outlet to the end-use destination, including end-use combustion

Each of the global oils included in the database has an individual emissions footprint, based on their unique chemical composition, extraction and refining technologies, and other factors. These differences add up to high variability in lifecycle emissions from oil produced at different oil fields, and a better understanding of these differences can inform policy making designed to achieve climate goals and protect local air quality. According to Deborah Gordon, the former director of the Carnegie Endowment for International Peace Energy and Climate Program (an OCI funding partner):

"California today stands at two ends of a spectrum: the nation's climate policy leader is also the country's third largest oil-producing state and the state with the third largest oil-refining capacity in the nation. Despite ambitious goals to reduce carbon emissions, some California oils are as high-emitting as Canadian oil sands and other difficult-to-extract heavy oils. This poses critical global climate risks and calls for immediate policy attention."[3]

CRUDE OIL EMISSIONS FACTORS

OCI provides emissions factors specific to each of the lifecycle phases (i.e., upstream, midstream, downstream) expressed as kilograms of carbon dioxide equivalent (kg CO_2e) per barrel of crude oil.[4] OCI does not have emissions factors specific to the Long Beach oil fields; the Wilmington oil field is the closest option geographically. AECOM consulted with CARB staff about using Wilmington as a proxy for the Long Beach fields, and were informed that the LCFS Regulation does include upstream emissions factors specific to the Long Beach fields, which could be combined with midstream and downstream factors from OCI to develop a more nuanced and locally-specific emissions factor. CARB staff suggested that OCI's midstream and downstream emissions factors for Wilmington might be a good proxy for Long Beach in lieu of more specific analysis. AECOM staff contacted a co-developer of the OCI database to discuss this question further and understand if Long Beach oil field-specific factors are available, but did not receive a response prior to developing this memo. Therefore, the lifecycle emissions factor for oil production used in this analysis is based on the best available data and consists of the components shown in Table 1.

Table 1 – Crude Oil Lifecycle Emissions Factors

Sector	kg CO_2e/barrel of crude	Source
Upstream Emissions[1]	**32.6**	CARB
Midstream Emissions[2]	**90.0**	OCI - Wilmington
Heat	27.0	
Electricity	5.0	
Steam	6.0	
Hydrogen (via steam methane reformer)	47.0	
Catalyst Regeneration (fluid catalytic fracking)	5.0	
Downstream Emissions[2]	**478.0**	OCI - Wilmington
Transport to Consumers	12.0	

[3] Gordon, Deborah and Samuel Wojcicki. Need to Know: The Case for Oil Transparency in California. Carnegie Endowment for International Peace. March 15, 2017. Available: <https://carnegieendowment.org/2017/03/15/need-to-know-case-for-oil-transparency-in-california-pub-68166>

[4] The emissions factors from OCI do not account for natural gas extraction, distribution, or use, so additional lifecycle emissions estimates were developed to analyze this emissions source from production in Long Beach.

Sector	kg CO_2e/barrel of crude	Source
Gasoline	213.0	
Jet Fuel	43.0	
Diesel	137.0	
Petroleum Coke	40.0	
Residual Fuels	17.0	
LPG	16.0	
Total	**600.6**	Calculated value

[1] California Air Resources Board Low Carbon Fuel Standard Regulation, Unofficial Electronic Version provided to AECOM via email April 2019. Table 9 - Carbon Intensity Lookup Table for Crude Oil Production and Transport. Conversion from g CO_2e/MJ to kg CO_2e/barrel of crude provided to AECOM via email by CARB staff.

[2] Oil-Climate Index, "U.S. California Wilmington" Created 2015. Accessed 4/12/2019. Available: <https://oci.carnegieendowment.org/?toggle-carbon=on&carbon-tax=20&ratio-select=perBarrel&step-select=ghgTotal&sort-select=true#oil/u.s.-california-wilmington>

The total lifecycle emissions factor developed for this analysis is approximately 601 kg CO_2e per barrel of oil. Of this total, 5% of emissions occur upstream (e.g., extraction), 15% occur midstream (e.g., refining), and 80% of the emissions occur downstream from transport to consumers and final product use (e.g., gasoline, diesel, jet fuel).

Natural Gas Emissions Factors

The OCI emissions factors do not include emissions occurring from natural gas that is produced as a byproduct of the oil extraction process. To account for these emissions in Long Beach, the total natural gas production volume in the city was estimated and then organized according to its final end use to determine the applicable emissions factors. Of the natural gas produced in Long Beach, approximately 99% is combusted, either for auxiliary energy use at oil facilities or in building appliances and systems, like hot water heaters and stoves. The remaining 1% is fugitive emissions, lost to the atmosphere through leakage in the natural gas supply chain.

EPA emissions factors for stationary combustion of natural gas were applied to the volume of combusted natural gas. Table 2 summarizes these natural gas emissions factors.

Table 2 – Natural Gas Combustion Emissions Factor

Value	Unit	Source
0.05444	kg CO_2 per scf	U.S. EPA emissions factors[1]
0.00103	g CH_4 per scf	
0.0001	g N_2O per scf	
0.054	Total kg CO_2e per scf	Calculated value[2]

[1] U.S. EPA. Last modified 9 March, 2018. Available: <https://www.epa.gov/sites/production/files/2018-03/documents/emission-factors_mar_2018_0.pdf>

[2] Global warming potential factors for CH_4 and N_2O were used to convert to carbon dioxide equivalent; the UN IPCC Fourth Assessment Report values were used for consistency with the city's production-based GHG inventory. Available: <https://www.ipcc.ch/site/assets/uploads/2018/02/ar4-wg1-chapter2-1.pdf>

Fugitive emissions were estimated based on the amount of methane in the volume of lost natural gas, combined with its relative global warming potential (GWP) factor from the International Panel on Climate Change Fourth Assessment Report (IPCC 4AR).[5] Use of these GWP values provides consistency with the city's production-based inventory, which also uses 4AR 100-year GWP factors.

Total Emissions

The emissions factors presented above were combined with oil and natural gas production information from the City Energy Resources Department. Oil production data was provided in barrels per quarter from 2001-2017; 2015 values were used in this analysis for consistency with the city's production-based inventory. The City does not directly track natural gas production, and instead provided a factor to estimate total natural gas produced as a result of total oil produced. However, the Thums oil facility does report oil and natural gas production volumes to the EPA. This data was combined with the natural gas production factor provided by the City to estimate total natural gas production in Long Beach. Oil and gas production volumes for 2015 are shown in Table 3.

Table 3 – 2015 Oil and Natural Gas Production

2015 Production	Volume	Unit	Source
Crude Oil			
Total Oil Production	**13,321,018**	**barrels**	City of Long Beach Energy Resources Department
Natural Gas			
Thums Gas Production	3,450,425	Mcf	EPA GHG Reporting Protocol
Thums Oil Production	8,936,765	barrels	EPA GHG Reporting Protocol
Remaining Oil Production in Long Beach	4,384,253	Barrels	Calculated as (Total oil production) – (Thums oil production)
Gas Production Factor	0.38	Mcf/barrel	Provided by staff from Long Beach Energy Resources Department
Remaining Gas Production	1,666,016	Mcf	Calculated as (Gas production factor) * (Remaining oil production)
Total Natural Gas Production	**5,116,441**	**Mcf**	Calculated as (Thums gas production) + (Remaining gas production)

Based on the emissions factors and production volumes presented above, AECOM calculated total lifecycle emissions from the oil and gas produced in the city in 2015. As shown in Table 4, 96% of the emissions are attributed to oil and the remaining 4% are from natural gas. For comparison, the table also shows the city's 2015 production-based inventory emissions that are addressed in the City's draft CAAP. The lifecycle emissions from oil and gas produced in Long Beach are 2.7 times greater than the production-based inventory emissions generated as a result of activity in the community (e.g., residential energy use, on-road transportation, waste disposal). It is also worth noting that these emissions are approximately 1.2 times greater than the Long Beach consumption inventory, which represents the full

[5] International Panel on Climate Change, 2007. Changes in Atmospheric Constituents and in Radiative Forcing. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Available: <https://www.ipcc.ch/site/assets/uploads/2018/02/ar4-wg1-chapter2-1.pdf>

lifecycle emissions generated by the production, shipping, use, and disposal of each product consumed in Long Beach, regardless of where the GHG emissions were released to the atmosphere.

It should be noted that the production-based inventory methodology used to calculate the communitywide emissions does not use a lifecycle emissions approach. Therefore, the comparison of these two emissions values shown in Table 4 is for informational purposes only, and the two values should not be summed to represent a total emissions inventory for Long Beach.

Table 4 – 2015 Emissions Summary from Long Beach Oil and Gas Production

2015 Emissions	MT CO_2e
Oil and Gas Lifecycle Emissions	**8,329,292**
Oil Production	8,000,604
Natural Gas Production	328,689
Community Inventory Emissions (production-based inventory)	**3,100,468**

2. Long Beach Carbon Intensity Compared to Other Areas

The carbon intensity of a barrel of crude oil is not homogenous across all oil fields. Various factors influence oil's carbon intensity, including differences in physical characteristics, as well as in how the oil is extracted, processed, and ultimately used. Certain physical properties are used to characterize oil. For example, "sweetness" is defined by the sulfur content of the crude - the lower the content, the sweeter the oil. "Heavy" oils are those which have a lower API gravity (equivalent to specific gravity expressed as weight per volume) and conversely, light oils are those with higher API gravity.

OCI Lifecycle Emissions

The physical properties for a sample of six global oils from the OCI are shown in Table 5, including the Wilmington oil field that was used to estimate the midstream and downstream emission factors for Long Beach as referenced in Table 1. The selected oils also include the most carbon intensive in the OCI (Canada Athabasca DC SCO), the least carbon intensive (U.S. Texas Eagle Ford Volatile Oil Zone), the largest producer by volume (Saudi Arabia Ghawar), and the two other California oils surveyed in the OCI.

Table 5 – Physical Properties of Various Crude Oils

Oil Name	Oil Type	Classification	API	Sweet or Sour	Sulfur Content
U.S. Texas Eagle Ford Volatile Oil Zone	Condensate	Ultra-light	50	Sweet	0.13%
Saudi Arabia Ghawar	Light	Light	33	Sour	1.63%
U.S. California Wilmington Oil	Depleted	Heavy	19	Sour	1.56%
U.S. California Midway Sunset	Depleted	Medium to extra-heavy	23	Sour	1.19%
U.S. California South Belridge	Depleted	Heavy to extra-heavy	15	Sweet	0.25%
Canada Athabasca DC SCO	Extra-heavy	Extra-heavy	33	Sweet	0.16%

Source: Oil-Climate Index; adapted by AECOM 2019

Wilmington oil is characterized as heavy and sour. The use of pumps to extract a watery, depleted crude from the Wilmington reservoir generate most of its upstream GHG emissions. As noted above, this analysis uses an upstream emissions factor specific to the Long Beach crudes. Per input from CARB staff, Long Beach crudes inject less water than in Wilmington to produce the same amount of oil. Long Beach crudes also have a higher API than Wilmington crudes. These two factors result in lower upstream emissions from Long Beach crudes than Wilmington. This analysis uses Wilmington emissions factors for the midstream and downstream lifecycle phases. When Wilmington crude is refined, petcoke (or petroleum coke) is produced. This product has a high carbon and low hydrogen content that, when exported and combusted, contributes significantly to Wilmington's downstream GHG emissions.[6]

Heavy oils like Wilmington's or extra heavy oils like Canada Athabasca DC SCO (Athabasca) or the other U.S. California oils require more energy resources to extract and to separate out the usable fractions. Wilmington has higher midstream emissions than many other OCI oils because of the amount of hydrogen and heat used to transport and store the oil. Crudes like those found at Texas Eagle Ford Volatile Oil Zone (Texas Eagle) are considered ultra-light, sweet and relatively easy to extract from their source material. Sour oils such as Wilmington also have higher sulfur content (1.56% sulfur) than sweet oils and therefore require greater desulfurization at the midstream refining level.

Table 6 shows the emissions by lifecycle phase (e.g., upstream) for the same six global oils presented in Table 5, along with the approximated Long Beach oil emissions factor, ranked from lowest lifecycle emissions to highest. Texas Eagle has the lowest overall carbon intensity of all 75 oils surveyed in the OCI, and Athabasca has the highest. Lifecycle emissions from Long Beach and Athabasca oils are 1.3 and 1.6 times greater than those extracted from Texas Eagle, respectively.

Table 6 – Oil Emissions by Field[7]

Oil-Climate Index Model	kg CO_2e/barrel of oil			
Oil Name	**Upstream**	**Midstream**	**Downstream**	**Total**
U.S. Texas Eagle Ford Volatile Oil Zone	33	23	403	458
Saudi Arabia Ghawar	34	28	430	491
Long Beach Oil[1]	33	90	478	601
U.S. California Wilmington Oil	56	90	478	625
U.S. California South Belridge	103	98	489	690
U.S. California Midway Sunset	180	81	464	725
Canada Athabasca DC SCO	163	13	560	736

[1] Rounded to nearest whole number; see Table 1 for emissions inputs for Long Beach Oil; Total values for OCI survey oils may not sum to total shown

As represented in the OCI, Wilmington oil has a standard emissions factor of 625 kg CO_2e per barrel, ranking it as tenth most carbon intensive of all 75 global oil types surveyed in the OCI. The approximated Long Beach oil emissions factor presented in Section 1 is 601 kg CO_2e/barrel oil, and would rank as the 14th most carbon intensive global oil in the OCI. Of the 75 global oils surveyed in the OCI, the median lifecycle emissions are 514 kg CO_2e per barrel; all three of the California oils in the OCI exceed the median value.

[6] Carnegie Endowment, Oil-Climate Index. Available <https://oci.carnegieendowment.org/?toggle-carbon=on&carbon-tax=20&ratio-select=perBarrel&step-select=ghgTotal&sort-select=true#oil/u.s.-california-wilmington>

[7] Carnegie Endowment, Oil-Climate Index. Available: <https://oci.carnegieendowment.org>

As shown in Table 6, Athabasca oils have the highest carbon footprint in the OCI at 736 kg CO_2e/barrel oil. Its high carbon footprint is largely attributable to the unconventional nature of the tar from which the oil must be separated in order to have a usable product; 22% of the total emissions occur from upstream processes alone for Athabasca. That compares to Texas Eagle (with the lowest total emissions in the OCI) at 458 kg CO_2e/barrel where 7% of emissions come from upstream operations. Upstream emissions from Long Beach oil (33 kg CO_2e/barrel oil), as informed by CARB's LCFS research, ranks among the lowest of those surveyed in the OCI; the lowest upstream emissions in the OCI are from U.S Wyoming WC at 21 kg CO_2e/barrel oil. The majority of Long Beach emissions come from downstream processes, comprising 80% of the total emissions profile, based on the assumption that Wilmington oils are a suitable proxy for Long Beach for midstream and downstream emissions.

CARB Crude Oil Upstream Carbon Intensity

The California Air Resources Board estimates the upstream and transport-related emissions for more than 100 California crude oil sources in its role of implementing the state's low carbon fuel standard (LCFS). The objective of the LCFS is to reduce the fuel-cycle carbon intensity of transportation fuels used in California. For this analysis, CARB staff provided a link to the Unofficial Electronic Version of the 2019 LCFS Regulation for reference, and recommended that the Long Beach-specific upstream carbon intensity factor included therein could be used to replace the Wilmington upstream emissions factor from the OCI.

The information provided by CARB includes carbon intensity values for 157 California oil fields, expressed as gCO_2e/MJ. The lowest carbon intensity factor is from the Olive oil field (1.82 gCO_2e/MJ), the highest carbon intensity is from the Chico-Martinez oil field (48.13 gCO_2e/MJ), and the median carbon intensity is 4.94 gCO_2e/MJ. The Long Beach oil field carbon intensity is 5.48 gCO_2e/MJ; 94th out of 157 when ranked lowest to highest. For comparison, the Wilmington oil field carbon intensity listed in the LCFS is 8.31 gCO_2e/MJ, or 118th out of 157. This suggests that even among other California oil fields, the majority have a lower carbon intensity value than Long Beach oil.

3. What Happens to Oil and Gas Extracted in Long Beach

This section briefly outlines the assumed final destination of oil and gas produced in Long Beach. The primary takeaway is that there is imperfect tracking of the oil and gas produced in Long Beach and elsewhere in the state, so inferences have been made based on various sources of information to estimate where the city's oil and gas production might go.

Oil

It is assumed that all oil produced in Long Beach is eventually consumed within the state. In 2018, 31.1% of the crude oil supply for California refineries was produced in-state, 11.4% was imported from Alaska, and 57.5% was imported from abroad. Foreign sources of crude oil imports came from more than 10 countries in 2018, with the largest imports from Saudi Arabia (37%), Ecuador (14%), and Colombia (13%).[8] According to the EIA, "California is the second largest consumer of petroleum products in the nation and the largest consumer of motor gasoline and jet fuel."[9] On a statewide average, 66% of crude oil product from California refineries is motor gasolines, 13% is distillate fuel, 12% is aviation fuel, and 9%

[8] California Energy Commission. Oil Supply Sources to California Refineries. Available: <https://www.energy.ca.gov/almanac/petroleum_data/statistics/crude_oil_receipts.html>
[9] EIA. California State Profile and Energy Estimates. Last updated November 15, 2018. Available: <https://www.eia.gov/state/analysis.php?sid=CA>

is residual fuel.[10] This information suggests that California consumes all of its domestic oil production, including that from Long Beach, and needs additional imports to satisfy in-state demand.

As a caveat to this assumption, it is possible that petcoke is produced as a byproduct of refining Long Beach oil; petcoke combustion is a contributor to downstream emissions from Wilmington oils in the OCI, and the same emissions factors were used as a proxy for Long Beach oil given the oils' similar characteristics. Strict state and federal regulations make combustion of petcoke difficult in the U.S., which limits the domestic market. According to a 2013 CBS report, "California exports 128,000 barrels of petroleum coke a day. Most of it goes to China, where it's burned to generate electricity, and where it emits five to 10 percent more carbon dioxide than coal."[11] The Port of Long Beach website also lists petroleum coke as a top export item.

Natural Gas

The City of Long Beach operates one of the largest municipally owned natural gas utilities in the U.S., and is one of only three such operations in California. According to the *2016 California Gas* Report prepared by the California Gas and Electric Utilities:

"Long Beach receives a small amount of its gas supply directly into its pipeline system from local production fields that are located within Long Beach's service territory, as well as offshore. Currently, Long Beach receives approximately 5 percent of its gas supply from local production. The majority of Long Beach supplies are purchased at the California border, primarily from the Southwestern United States. Long Beach, as a wholesale customer, receives intrastate transmission service for this gas from SoCalGas."[12]

As presented in Table 3, this analysis estimated that Long Beach produced 5.1 million Mcf of natural gas in 2015. It is further assumed that 100% of the natural gas produced in Long Beach is consumed within the city as well. Of the total gas production volume, approximately 1.4 million Mcf is assumed to be distributed as natural gas for local consumption, while the remainder is primarily combusted on-site during oil production or to generate auxiliary energy at the oil fields; a fraction (1.44%) is also assumed for total leak loss from the natural gas supply chain. Based on the city's total natural gas production estimate, approximately 3.1% of natural gas consumed in the city (as represented in the production-based inventory) is produced locally.

Implications of Oil and Gas Use from Long Beach

As was described in the previous sections, oil emissions account for 96% of total lifecycle emissions from oil and gas extracted in Long Beach. Further, while the upstream emissions of local oil extraction are relatively low when compared to global oils in the OCI, the total lifecycle emissions from Long Beach oil are relatively much higher than other sources. This suggests that as the city and other global actors (e.g., cities, countries) strive to reduce fossil fuel use over the long-term, there are lower carbon-intensive oil options available that could be used in the interim as economies shift away from fossil fuels.

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[10] California Energy Commission. California's Oil Refineries. Available: <https://www.energy.ca.gov/almanac/petroleum_data/refineries.html>
[11] CBS SF Bay Area. Dirty Substance from California's Oil Refineries Burned Overseas. October 1, 2013. Available: <https://sanfrancisco.cbslocal.com/2013/10/01/dirty-substance-from-californias-oil-refineries-burned-overseas/>
[12] 2016 California Gas Report. Page 101. Available: <file:///C:/Users/lathanj1/Downloads/TN212364_20160720T111050_2016_California_Gas_Report.pdf>

4. State Regulations of Gas and Oil Operations

This section gives a generalized overview of the state regulatory framework applicable to the oil and gas industry.

California Air Resources Board

In March 2017, CARB adopted its "Methane Regulations", which impose emission controls for on- and offshore oil production and processing facilities, as well as natural gas distribution facilities. The intent of the regulations is to help the state to achieve its GHG reduction targets codified in Assembly Bill 32 and Senate Bill 32 through the oil and gas industry. The regulation is designed to reduce methane emissions from oil and gas operations, which account for approximately 4% of methane emissions in the state.[13] The regulations include stringent best management practices for vapor collection and flow rate measurements from well casing vents, among other things. The regulations also include plans to implement advanced Leak Detection and Reporting programs (LDAR) that exceed the current industry practice.[14] The anticipated impact of the regulations includes average methane reductions of 1.4 million MT CO_2e/year (based on a 20-year GWP value), reductions of over 3,600 MT/year in volatile organic compounds (VOCs) statewide, and reductions of more than 100 MT/year in toxic air contaminants.[15]

CALIFORNIA CAP-AND-TRADE PROGRAM

In 2006, California took steps to develop a long-term response to the challenges of climate change through adoption of Assembly Bill 32, which includes California's Cap-and-Trade regulation as one of 70 separate measures used to reduce GHG emissions in the state.[16] The Cap-and-Trade program established a declining cap on carbon emissions and a framework in which companies can trade emission allowances to achieve statewide GHG reduction objectives. Organizations registered in the program account for 80% of California's overall GHG emissions.

The Cap-and-Trade program mandates that companies account for GHG emissions by acquiring credits (allowances) and retiring them with the state. Companies are also permitted to purchase a limited number of offsets to achieve compliance. According to CARB, emissions from oil and gas production decreased slightly (by 0.9%) from 2016 to 2017 partially as a result of the Cap-and-Trade program.[17]

The California Resources Corporation (CRC), which operates the THUMS Long Beach Company and the Tidelines Oil Production Company (both within the city boundary), is subject to California's Cap-and-Trade program requirements. From 2013-2017, CRC has spent $148 million to purchase GHG allowances at auction and purchase sustainable forestry offsets.[18]

South Coast Air Quality Management District

The South Coast Air Quality Management District (SCAQMD) is the air pollution control agency for a southern California region that includes Long Beach and nearly half of the state's population. SCAQMD's

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[13] California Air Resources Board. Oil and Natural Gas Production, Processing, and Storage. Available: <https://ww2.arb.ca.gov/our-work/programs/oil-and-natural-gas-production-processing-and-storage/about>
[14] Stoel Rives, LLP. California Environmental Law: ARB Adopts GHG Emission Standards for Oil and Gas Facilities; Operators Wary of Costs. Available: <https://www.californiaenvironmentallawblog.com/oil-and-gas/arb-adopts-ghg-emission-standards-for-oil-and-gas-facilities-operators-wary-of-costs/>
[15] California Air Resources Board. Oil and Gas Methane Regulation, Standards and Implementation. Available: <https://ww2.arb.ca.gov/resources/fact-sheets/oil-and-gas-methane-regulation>
[16] Environmental Defense Fund. AB 32 Cap-and-Trade Rule Fact Sheet. Available: <https://www.edf.org/sites/default/files/EDF-CA-CT-Fact-Sheet-August-2011.pdf>
[17] California Air Resources Board. 100 Percent of Companies in Cap-and-Trade Program Meet 2015-2017 Compliance Requirements. Available: <https://ww2.arb.ca.gov/news/100-percent-companies-cap-and-trade-program-meet-2015-2017-compliance-requirements>
[18] California Resources Corporation. Greenhouse Gases. Available: <http://www.crc.com/sustainability/energy-conservation-efficiency/greenhouse-gases>

primary role is to control stationary emissions sources, such as oil refineries, power plants, and gas stations, as well as consumer products like paint and solvents. Other relevant emissions sources regulated by SCAQMD include oil and gas storage vessels, equipment leaks at gas processing plants, and fugitive emissions at wells. SCAQMD has an Air Quality Management Plan that outlines how the agency will comply with federal and state clean air standards through adoption of rules and regulations that manage stationary emitters. The agency has permitting authority, which helps to implement and monitor its air quality rules. SCAQMD also continuously monitors air quality to track overall progress toward the agency's goals and notify the public of unhealthy conditions. Various SCAQMD rules may apply to oil and gas operations, depending on the specific type of operation. For example, Regulation XI – Source Specific Standards includes several rules for oil and gas well operators with the purpose to reduce emissions from VOCs, toxic air contaminants (TACs), and total organic compounds (TOCs).

Division of Oil Gas and Geothermal Resources

The Division of Oil Gas and Geothermal Resources (DOGGR) oversees drilling, operation, maintenance, and plugging/decommissioning of abandoned oil, natural gas, or geothermal wells. All statutes and regulations are codified in the California Department of Conservation, Oil, Gas and Geothermal Resources document titled "Statues & Regulations – April 2019".[19] DOGGR maintains records on retired, existing, and active wells in the state. An important aspect of DOGGR's work is oversight of well abandonment to ensure that idle wells (i.e., inactive for two or more years) are properly plugged to avoid oil and gas leaks into water supplies or to the surface. DOGGR also regulates infrastructure within oil fields from the wellheads to the sales meter. This oversight includes infrastructure like storage tanks, pumps and valves, compressors, and oil and gas production pipelines.

Case Study: Synergy Oil Wetlands Restoration and Oil Consolidation Project

As part of this analysis, staff from Synergy Oil were interviewed to better understand specific reporting requirements to various agencies and to learn about their wetland restoration and operational efficiency improvement efforts. Synergy Oil has implemented a comprehensive wetlands restoration project, restoring a privately-owned oil field in Long Beach using a wetlands mitigation bank in order to reduce the overall GHG emissions impact. Synergy Oil restored a total of 150 acres of wetlands. An additional 33 acres owned by the City of Long Beach will be restored in the near future as well. Per the project's environmental impact report (EIR), all of Synergy Oil's operations will be concentrated and consolidated from the Synergy Oil Field and Long Beach-owned property to two off-site properties (i.e., Los Cerritos Wetland Authority and Pumpkin Patch Site).[20]

According to the Los Cerritos Wetlands Restoration and Oil Consolidation Draft EIR, the specific project objectives are to:

1. Restore the historic tidal connection to a greater portion of the degraded Los Cerritos Wetlands through establishing a wetlands mitigation bank that will result in restoration and creation of a self-sustaining 78-acre restored coastal wetlands habitat, including habitat for special-status plant and animal species.
2. Restore tidal salt marsh habitat and associated subtidal, intertidal, transitional, and upland habitats, taking into consideration potential sea level rise due to climate change.
3. Improve the efficiency of oil production operations through the eventual phase out of early-20th-century oil production equipment and replacement with more-efficient and modern equipment and

[19] California Department of Conservation - Oil, Gas, & Geothermal Resources. Statutes and Regulations, April 2019. Available: <https://www.conservation.ca.gov/index/Documents/DOGGR-SR-1%20Web%20Copy.pdf>
[20] City of Long Beach Planning Department. Environmental Reports. Available: <http://www.lbds.info/planning/environmental_planning/environmental_reports.asp>

operations that will utilize the latest technology and operational advancements related to safety, energy, and production efficiency and concentrate production on a smaller footprint.

4. Protect coastal-dependent energy development by optimizing oil and gas production from the oil reserves within the City's jurisdiction that will help fund the costs of wetlands restoration, and continue to provide a source of revenue to the City of Long Beach, as well as short-term and long-term employment opportunities.
5. Help achieve statewide goals of sustainability by reducing reliance on foreign oil and inter-state natural gas pipelines by developing locally-sourced and consumed resources using energy-efficient technology.
6. Reduce energy use environmental impacts, efficiently use project-sourced natural gas, and increase project reliability/safety with a microgrid that integrates multiple on-site energy sources with high-efficiency controls on energy-using equipment.[21]

5. Near-term Recommendations – Technological Interventions to Minimize Lifecycle Emissions

This section provides short-term strategy recommendations for reducing GHG emissions through emission control technology and mitigation actions. This list includes a set of recommendations that focus primarily on minimizing process and fugitive emissions associated with upstream petroleum and natural gas production as this is the primary process in the City's control. Brief recommendations for midstream and downstream actions are summarized, as applicable.

The recommendations were developed to correspond closely to the sources of lifecycle emissions identified in the previous sections of this memo. The recommendations presented are high-level opportunities, and are not site-specific or based on an analysis of existing operations at the various oil production facilities in Long Beach. The recommendations are intended to represent opportunities to exceed the minimum compliance levels of current regulations. Several advocacy recommendations are also included for emissions sources or regulatory opportunities over which the City does not have direct control.

Upstream Emissions Reductions

1. Expand current emission control requirements to further capture greenhouse gas emissions.

The U.S. EPA has a voluntary GHG reduction program for oil and gas operations called Natural Gas STAR that provides guidance on methane control technologies.[22] Participants in the program have contributed to the development of a library of tools and technical resources that other oil and gas operators can incorporate into day-to-day operations to evaluate and implement emissions reduction actions. Based on Natural Gas STAR program recommendations, the following opportunity for emissions control technology could potentially be implemented at Long Beach oil facilities:

- **Install vapor control technology that is adequately sized for the maximum amount of vapor on tanks**. Under CARB, emission controls are only required for tanks with emissions greater than 10 metric tons of methane per year. Based on the "lessons learned" studies from the Natural Gas STAR program, vapor recovery unit systems should be sized to handle the maximum volume of vapors expected from storage tanks. As additional guidance, Noble Energy has developed a

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[21] ESA. Los Cerritos Wetlands Oil Consolidation and Restoration Project Draft Environmental Impact Report. Executive Summary. July 2017. Available: <http://www.lbds.info/civica/filebank/blobdload.asp?BlobID=6663>

[22] U.S. EPA (2015a). EPA's Natural Gas STAR Program. Available: < https://www.epa.gov/natural-gas-star-program/natural-gas-star-program>

modeling guideline that can be used to determine the potential peak instantaneous vapor flow rate.[23]

2. **Implement energy efficiency improvements at oil facilities to reduce the amount of energy required to produce each barrel of oil.**

CARB released the *Energy Efficiency and Co-Benefits Assessment of Large Industrial Sources Refinery Sector Public Report* (Oil Refinery Sector Report) on June 6, 2013.[24] The report included an assessment of energy efficiency opportunities at California's oil refineries, including opportunities for boiler equipment. While boilers used at refineries tend to be substantially larger units than those used in oil production fields, boilers are likely a significant source of emissions at Long Beach oil facilities regulated under the Cap-and-Trade program. Therefore, boiler efficiency opportunities could reduce the upstream carbon intensity values of oil produced, while also minimizing the amount of carbon allowance purchases needed to maintain compliance with the Cap-and-Trade program. The findings in the report may be useful in lieu of an oil production sector-specific report.

3. **Require oil producers to report natural gas production volumes and final destination of gas to the City.**

The estimates of natural gas production and end of life use (e.g., combustion on-site, flaring, sales) in this analysis were developed from various sources with differing levels of quality. While lifecycle natural gas emissions only represent 4% of the total oil and gas emissions, the various assumptions required to develop that estimate provide room for inaccuracy. Better natural gas accounting would improve this segment of the lifecycle analysis and could help identify more impactful intervention opportunities. The City should collect information on the volumes of natural gas from Long Beach oil fields that are flared, combusted during oil production, combusted on-site for auxiliary energy use, and sold for distribution in the natural gas transmission system.

Upstream Emissions Detection

Under the CARB methane regulations, quarterly leak detection and repair (LDAR) inspections using Method 21 (M21) and daily audio visual inspections are required at upstream oil and gas facilities, including well sites and natural gas gathering plants at a threshold of 1,000 parts per million (ppm). According to the EPA's Control Techniques Guidelines for the Oil and Natural Gas Industry, M21 inspections conducted on a quarterly basis reduce fugitive emissions by an estimated 80%.[25] The flame ionization detector used in M21 provides a concentration of VOCs and methane at the sampling point, but does not provide a visual of the leak source. This method has been used for over 20 years in downstream oil and gas operations. For upstream oil and gas operations, technological advances have been made that can better identify leaks. The recommendations below represent an advocacy approach where the City can demonstrate support for more stringent leak detection or the required use of newer technologies. The City may also be able to directly pursue these strategies through use of its oil facility permitting authority.

[23] Noble Energy, Inc. (2015, May 21). Noble Modeling Guideline, Well Site Tank System. Semi-Annual Report, Appendix B.
[24] California Air Resources Board, Stationary Source Division. Energy Efficiency and Co-benefits Assessment of Large Industrial Sources, Refinery Sector Public Report. June 6, 2013. <https://www.arb.ca.gov/cc/energyaudits/eeareports/refinery.pdf>

[25] U.S. EPA (2016). Control Techniques Guidelines for the Oil and Natural Gas Industry. Page 9-20 and 9-21. Available: <https://www.epa.gov/sites/production/files/2016-10/documents/2016-ctg-oil-and-gas.pdf>

4. Advocate for development of a process to approve and incorporate alternative technologies for use in CARB compliance.

The largest emissions are often episodic;[26] requiring continuous emission monitoring would support quicker corrective action and better emission source characterization. Recently, there have been major advancements in continuous monitoring technologies.[27] However, there is currently no path to request approval to use these technologies as an alternative inspection method from CARB or SCAQMD. The City can advocate for a process that allows companies to have new leak detection technologies approved for use in regulation compliance.

5. Advocate for CARB to implement a quarterly pneumatic LDAR protocol.

Current CARB regulations require annual measurement of low-bleed and intermittent pneumatic devices, with no specific guidance on the measurement method. A recent study on gathering station emissions found that 42% of measured pneumatic devices had abnormal emission patterns,[28] and abnormal emissions from intermittent controllers were found to be over five times higher than those operating normally. Under the current M21 requirement for LDAR, it is difficult to assess if a device was operating properly in a quarterly leak inspection because of the nature of a concentration-only device used during inspections. Allowing for optical gas imaging as an alternative approach for LDAR survey would support accurate identification of the leak source and a visualization of the emission pattern of the device. Implementing an LDAR protocol specific for pneumatics on a quarterly basis would further reduce lifecycle emissions. Guidance documents on including pneumatics in an LDAR protocol are expected to be available in the near future from the American Petroleum Institute (API) and the Colorado Air Pollution Division.

Midstream and Downstream Emissions Reduction

6. Increase utility sector leak detection.

Studies have found that current assumptions may be underestimating distribution and end-of-use emissions in the natural gas supply chain.[29] The EPA National Emission Inventory natural gas distribution emissions were used, in part, to derive the city's natural gas lifecycle emissions in this analysis. This approach estimated that 0.2% of natural gas production is lost in the lifecycle of this sector. However, regional studies have estimated that this value could be as much as 3.5% of production.[30] A study that analyzed downstream emissions in Boston, showed that as much as 2.7% of natural gas in the end user utility sector was lost due to leaks.[31,32] Although downstream and end user emissions are estimated to be

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[26] Alvarez, Ramón & Zavala-Araiza, Daniel & R. Lyon, David & T. Allen, David & R. Barkley, Zachary & Brandt, Adam & Davis, Kenneth & C. Herndon, Scott & J. Jacob, Daniel & Karion, Anna & A. Kort, Eric & Lamb, Brian & Lauvaux, Thomas & D. Maasakkers, Joannes & J. Marchese, Anthony & Omara, Mark & W. Pacala, Stephen & Peischl, Jeff & L. Robinson, Allen & Hamburg, Steven. (2018). Assessment of methane emissions from the U.S. oil and gas supply chain. Science. 361. eaar7204. 10.1126/science.aar7204.

[27] https://arpa-e.energy.gov/?q=program-projects/MONITOR

[28] Multiday Measurements of Pneumatic Controller Emissions Reveal the Frequency of Abnormal Emissions Behavior at Natural Gas Gathering Stations Luck et al Environmental Science & Technology Letters Article ASAP DOI: 10.1021/acs.estlett.9b00158

[29] Alvarez, Ramón & Zavala-Araiza, Daniel & R. Lyon, David & T. Allen, David & R. Barkley, Zachary & Brandt, Adam & Davis, Kenneth & C. Herndon, Scott & J. Jacob, Daniel & Karion, Anna & A. Kort, Eric & Lamb, Brian & Lauvaux, Thomas & D. Maasakkers, Joannes & J. Marchese, Anthony & Omara, Mark & W. Pacala, Stephen & Peischl, Jeff & L. Robinson, Allen & Hamburg, Steven. (2018). *Assessment of Methane Emissions from the U.S. Oil and Gas Supply Chain*. Science. 361. eaar7204. 10.1126/science.aar7204.

[30] Brandt, Adam & Heath, Garvin & A Kort, E & O'Sullivan, F & Petron, Gabrielle & Jordaan, Sarah & Tans, P & Wilcox, Jennifer & M Gopstein, A & Arent, Doug & Wofsy, Steven & J Brown, N & Bradley, R & D Stucky, G & Eardley, D & Harriss, Robert. (2014). *Methane Leaks from North American Natural Gas Systems*. Science (New York, N.Y.). 343. 733-5. 10.1126/science.1247045.

[31] ibid

[32] Kathryn McKain, Adrian Down, Steve M. Raciti, John Budney, Lucy R. Hutyra, Cody Floerchinger, Scott C. Herndon, Thomas Nehrkorn, Mark S. Zahniser, Robert B. Jackson, Nathan Phillips, Steven C. Wofsy. *Methane Emissions from Natural Gas Infrastructure and Use in the Urban Region of Boston, Massachusetts.* Proceedings of the National Academy of Sciences Feb 2015, 112 (7) 1941-1946; DOI: 10.1073/pnas.1416261112

a minor source of lifecycle GHG emissions in Long Beach, there is potentially an opportunity to reduce these emissions by locating end-user leaks through additional detection around meters and at pumps and compressors.

7. Dis-incentivize petcoke production and use.

Refining heavy crude oils, like those produced in Long Beach, can result in petcoke generation when a coking unit is used at the refinery. In general, extra-heavy oils generate 22% petcoke by volume, heavy oils generate 7% petcoke, and light or extra-light oils generate no petcoke.[33] Petcoke is a relatively inexpensive fuel source that can be used as a substitute for coal, but it has higher GHG emissions than coal or natural gas and can contribute to poor air quality due to its high sulfur content. Petcoke can also be used in certain industrial processes, such as cement production and manufacturing aluminum or other metals. As refineries in the U.S. continue to process heavy oils from Canada, Venezuela, and elsewhere, stockpiles of petcoke have grown substantially. According to a Carnegie-Tsinghua Center for Global Policy report, “faced with a substance that is produced in large volumes and costly to store, U.S. oil firms have become eager to sell petcoke to energy-hungry developing countries…”[34] As with many other recommendations in this memo, direct control of the petcoke challenge is outside the City’s control (with the exception of implementing a moratorium on oil extraction). The City could potentially advocate for long-term storage solutions for petcoke produced at U.S. refineries to dis-incentivize exports of the material. It could also advocate for investments in or greater regulation of U.S. refineries that process heavy crude oils to require installation of systems that support residue fuel hydrogenation to reduce the amount of petcoke produced.

6. Long-term Recommendations – Transition from Oil and Gas Activity

This section provides high-level, longer-term strategy recommendations to reduce lifecycle emissions from oil and gas production in Long Beach. It is important to note that based on the definition of lifecycle emissions used in this analysis, which includes emissions from extraction, refining and processing, and final consumption by end users, there are very few actions that could reduce these emissions entirely. Most of these actions would only result in reducing upstream and midstream emissions and shifting where the downstream emissions occur.

Upstream extraction emissions can be reduced through efficiency improvements that reduce the amount of energy required to produce each barrel of oil and through minimization of methane leaks, as described in Section 5. Similarly, midstream refining and processing emissions can be reduced through efficiency improvements as well. However, more than 75% of the City’s oil and gas lifecycle emissions are assumed to occur downstream where efficiency improvements do not help to avoid these emissions. For example, national vehicle efficiency requirements could significantly improve car fuel economy. The result would be that oil produced in Long Beach and refined into vehicle gasoline would be consumed with greater efficiency by vehicles, but would ultimately be combusted for power at which point the downstream emissions would still occur. Even if the City prohibited use of fossil fuels within its boundary, the oil and gas produced at City wells would be sold on the global energy market and consumed somewhere else to produce the downstream emissions component of the lifecycle emissions.

The City’s long-term approach to manage oil and gas lifecycle emissions should be multi-pronged to include the:

1. gradual phase-out of fossil fuel consumption in the city,

[33] Tao, Wang. *Managing China’s Petcoke Problem*. Carnegie-Tsinghua Center for Global Policy. May 2015. Available: <https://carnegieendowment.org/files/petcoke.pdf>
[34] ibid

2. advocacy and support for other jurisdictions to take the same bold action (domestically and abroad) resulting in decreased global demand for oil and gas produced in Long Beach,
3. gradual reduction in local oil and gas production, and
4. investment in carbon capture technology to offset lifecycle emissions from remaining local oil extraction activity.

Decrease Local Oil and Gas Consumption

The following recommendations primarily reduce the emissions accounted in the city's production-based inventory. If local oil and gas consumption is reduced, the energy resources produced in Long Beach would likely still be exported for use elsewhere, at which point the downstream emissions would occur.

1. Increase renewable natural gas supply with an organic waste-to-anaerobic digestion program. (Draft CAAP action)

As previously described, it is assumed that 100% of the natural gas produced in Long Beach is consumed in the city and natural gas imports are used to meet the remaining local demand. If the City's Energy Resources Department can procure renewable natural gas (RNG) for local use, this would help to further reduce the City's energy sector emissions in the production-based inventory. The draft CAAP includes actions to develop a robust organic waste collection program and identify opportunities for beneficial reuse of the waste stream, including anaerobic digestion at a regional facility that could potentially produce RNG. This action would help to decrease landfill emissions that occur from the anaerobic decomposition of organic waste materials and could also reduce building energy natural gas emissions.

2. Electrify public and passenger vehicle transportation. (Draft CAAP action)

Electric vehicles (EVs) have become more popular in recent years, in public transit fleets and for private passenger vehicles. The City can facilitate an increase in local use of EVs to reduce its reliance on vehicle fossil fuels. The draft CAAP includes actions to expand EV charging infrastructure communitywide in new construction and retrofits to existing buildings and properties, and to promote available financial incentives or rebate programs for EVs and associated charging equipment. The draft CAAP also includes a set of actions designed to increase non-vehicular trips in the community from walking, biking, or shared mobility options (e.g., electric scooters), and to minimize single occupancy trips through a transportation demand management program. These actions would also serve to reduce the community's vehicle fuel consumption.

3. Reduce building energy use through energy efficiency upgrades and electrification of end-use appliances. (Draft CAAP action)

Natural gas is consumed in homes and businesses in Long Beach for space and water heating, cooking, and producing on-site energy. Building energy efficiency improvements, like commercial retro-commissioning or hot water heater insulation, can reduce the amount of natural gas consumed in the community's buildings and facilities, which will reduce energy sector emissions in the production-based inventory. The draft CAAP includes several actions to increase building energy efficiency through a home energy audit program, improved access to technical assistance and financial resources or other incentives, and a public building energy audit and improvement program. Incentivizing building energy fuel switch opportunities, like converting from a gas boiler to an air source heat pump, will also support long-term GHG reduction goals in the community and is further enhanced as the share of renewables in the electricity grid increases.

4. Advocate for regional, state, and national oil and gas consumption reductions.

The above actions indicate what the City can do locally to reduce emissions from oil and gas consumption. However, if the energy resources produced locally are not consumed locally, they will find new users through the global energy market. Further, it is possible that all or most of the oil produced in Long Beach is consumed outside the city boundary, where the City has no jurisdictional control over the final end users. Long Beach can join other interested cities and organizations to advocate at the state and national level for action that results in further reductions in fossil fuel use. For example, more stringent vehicle fuel economy standards, improved regional and national public transit networks, enhanced EV incentive programs, stricter building energy codes, and improved access to financial resources for energy efficiency improvements. These actions would enable the City to indirectly support fossil fuel reductions on a larger scale through expanded implementation in other communities.

Decrease Local Oil and Gas Extraction

5. Phase-out local oil and gas extraction.

One of the most direct ways to reduce the city's oil and gas lifecycle emissions is to halt or severely curtail local fossil fuel extraction in the first place. Oil extracted in Long Beach oil fields has relatively higher carbon intensity per barrel than other global oils based on the oils surveyed in the OCI (i.e., 14th most carbon intensive overall). As noted elsewhere, this is due in part to the production of petcoke as a byproduct of the oil refining process, which contributes to downstream emissions when combusted to generate energy. Lower carbon-intensive oil sources are available to replace the supply produced in Long Beach, which would result in lower global oil emissions in general. For example, if Long Beach were to cease oil extraction operations altogether, it would be less carbon intensive to import oil from lower intensity areas like the Texas Ford Eagle field.

This strategy should be combined with actions to reduce fossil fuel use locally (see long-term recommendations 1-3 above), and advocacy efforts to reduce fossil fuel demand outside of Long Beach as well (see long-term recommendation 4 above). Further, this recommendation is based solely on the relative emissions intensity of global oil sources, and does not consider other potentially important factors like domestic energy security, wealth transfers to oil producing countries with poor human rights records, or other socio-political factors.

Support Carbon Capture Technology

6. Invest in direct air capture technology or other leading-edge technologies to reduce the global emissions impact from continued fossil fuel combustion.

The City may determine that economic, social, and environmental factors make local oil and gas extraction a preferable strategy over the long-term. Carbon capture technologies are being developed and implemented today, and the market for similar interventions will likely mature over time to become an important pathway to achieving the climate goals outlined in the 2016 Paris Agreement. Systems like direct air capture plants are envisioned as location-independent strategies that can be deployed to remove carbon from the atmosphere at an industrial scale. The goal is that these plants could also produce ultra-low carbon intensity transportation fuels from the captured CO_2. The plants could also be located at oil fields for use in enhanced oil recovery, which uses CO_2 to extract additional oil, and can then permanently store the CO_2 within the oil field reservoir. In the future, the City could dedicate a portion of its oil and gas revenue to help fund development of carbon capture facilities or to implement other carbon capture technology.

Increase Access to Information

7. Require oil field operators to report oil assays to CARB.

The City could advocate for CARB to require oil assays from operators within the state, and make the information publicly available to provide better understanding of the relative midstream and downstream emissions from California's oil fields. Per the Carnegie Endowment for International Peace, "California's oil ranks among some of the highest- and lowest-emitting worldwide."[35] Without accurate information on each oil field's oil composition, it is difficult to accurately estimate midstream refining emissions; "…this likely introduces error to estimated refining emissions on the order of plus or minus 50 percent."[36] Alternatively, the City could consider requiring assays as a permitting requirement for new and/or continued oil field operation. This oil field-specific information would help to better inform the City's opportunities to reduce its oil lifecycle emissions.

8. Consider including oil and gas lifecycle emissions in future Long Beach GHG target-setting and analysis.

To further support a more holistic understanding of the community's GHG emissions sources and reduction opportunities, the City can incorporate this type of oil and gas lifecycle emissions analysis in future CAAP updates. At that time, additional Long Beach-specific information may be available to further refine the initial analysis provided in this memo, including midstream and downstream emissions factors specific to the Long Beach oil field, verified natural gas production volumes, and greater detail on the final destination of oil and gas extracted in the city.

[35] Gordon, Deborah and Samuel Wojcicki. Need to Know: The Case for Oil Transparency in California. Carnegie Endowment for International Peace. March 15, 2017. Available: <https://carnegieendowment.org/2017/03/15/need-to-know-case-for-oil-transparency-in-california-pub-68166>

[36] ibid