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Renewable Diesel and the UrbanX Advantage

The Importance of -- and Major Demand for -- Increased Supply of Domestically Produced Renewable Diesel as a Mainstream Heavy-Duty Vehicle Fuel

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1. Executive Summary

Nationwide, on-road heavy-duty vehicles (HDVs) contribute approximately 50 percent of America's smog-precursor emissions and 20 percent of transportation-related greenhouse gas (GHG) emissions. In particular, "heavy-heavy-duty" semi-tractor trucks are the second largest and fastest-growing segment of the U.S. transportation system, for both energy use and emissions of harmful pollutants. Despite significant progress to gradually switch over to cleaner and renewable alternative fuels, America's transportation sector continues to almost totally rely on two fossil petroleum fuels: gasoline and diesel.

This dominance by fossil petroleum fuel in America's transportation sector results in major adverse environmental, health, and economic consequences. Over the last two decades, solid progress has been made to phase-in cleaner, lower-carbon-intensity transportation fuels. However, far-greater and faster progress is required. In fact, America's heavy-duty transportation sector needs systematic transformation to the cleanest-available HDV technologies and fuels, as soon as they are developed and commercialized.

An array of environmental and energy policies are gradually helping America develop and deploy emerging HDVs that deliver extremely low smog-precursor and GHG emissions. As this paper describes, one particular pathway – ultra-low-carbon-intensity **renewable diesel** used in existing or new diesel engines – has major potential to accelerate America's achievement of challenging air quality and climate change goals. Uniquely, this fuel-technology pathway can immediately provide a very low-emission solution for countless on- and off-road diesel engines, with no hardware costs or infrastructure changes.

Renewable diesel (RD) is essentially identical (chemically and structurally) to conventional diesel fuel. It is a low-carbon-intensity fuel that can simultaneously reduce emissions of both criteria pollutants and GHGs. RD is not biodiesel; it is free of the ester compounds found in biodiesel and has a much lower aromatic content. Unlike biodiesel, high-level blends of RD (including 100 percent) can be used in existing heavy-duty diesel engines and with existing infrastructure. It can be blended with conventional diesel in any amount, with no vehicle or equipment modifications required. RD has many good fuel qualities for compression-ignition engines, which enable it to provide similar (or better) vehicle performance compared to conventional diesel. It can be produced using existing oil refinery capacity; thus, extensive new production facilities will not be required for expanded RD use.

Some heavy-duty engine manufacturers have already fully approved use of RD, and others are expected to soon follow suit. The result is that this "drop-in" environmentally benign substitute for conventional diesel can immediately be used to power America's vast inventory of on- and off-road diesel engines. In fact, many major HDV fleets are now using RD to reduce fleet emissions and improve their "carbon footprint," with no new hardware costs. In California alone, more than 100 million RD gallons per year are being consumed today. While RD costs more to produce than conventional diesel, lucrative carbon-reduction credits (offered in California and the federal level) make it possible for retailers to sell RD at the same (or lower) price. Due to these various environmental and economic drivers, demand for RD is expected to continue growing in California and other states. However, large RD users (e.g., United Parcel Services) have found that insufficient volumes of RD are available to meet their expanding fleet demand and achieve corporate sustainability goals.

Meanwhile, the state of California has adopted very aggressive goals to displace conventional diesel with RD and other low-carbon-intensity renewable fuels. By 2031, it is expected that approximately **one billion RD gallons per year** will be needed in California alone. The major impediment to meeting this growing demand is the lack of current, cost-competitive domestic RD production using environmentally sustainable feedstock.

UrbanX Renewables Group (UrbanX), is the exclusive licensee of the Chevron Lummus Global (CLG) advanced RD process technology, known as the the Biofuels ISOCONVERSION (BIC) process. Fortunately, this innovative patented process technology gives UrbanX the unique competitive advantage of utilizing high-acid, waste-grade, cost-effective renewable Fat, Oil, and Grease (FOG) feedstock as its primary raw material, and converts the FOG into high yields of 100% drop-in, very-low-carbon-intensity, pure hydrocarbon fuels that meet or exceed petroleum fuels specifications. As described in this White Paper, UrbanX's RD process has numerous critical advantages over other RD producers and processes, and hold great promise to help meet California's growing demand for RD.

For these reasons, UrbanX seeks to raise an equity round of capital, which will be used to retrofit existing infrastructure at an identified idled petroleum refinery (Long Beach, CA), install the new exclusively licensed Chevron Lummus IsoConversion process technology equipment and begin its 5,000 Barrels Per Day (which will become the largest biorefinery west of the Mississippi River) RD production to serve California's growing demand for 100% drop-in renewable fuel.

2. Background and Introduction

This White Paper provides a brief overview on the importance of increasing domestic production of renewable diesel for use as a major low-emission fuel for America's heavy-duty transportation sector. For comprehensive corroboration that renewable diesel is a safe and proven substitute for conventional diesel fuel – with much lower GHG emissions – see Cal EPA's "Multimedia Evaluation of Renewable Diesel."[1]

2.1. Statement of the Problem and Market

Nationwide, on-road heavy-duty vehicles (HDVs) contribute approximately 50 percent of America's smog-precursor emissions and 20 percent of our transportation-related greenhouse gas (GHG) emissions. Heavy-duty trucks – primarily used to transport freight and goods – are the second largest and fastest-growing segment of the U.S. transportation system for both energy use and emissions of harmful pollutants. Despite significant progress to gradually move towards cleaner alternative fuels (renewable petroleum fuels, natural gas, hydrogen, and electricity), America's transportation sector continues to rely heavily on combusting two fossil petroleum fuels: gasoline and diesel. A very small, albeit growing, percentage of energy consumed in the U.S. transportation sector comes from renewable sources.

This dominance by fossil petroleum fuel in America's transportation sector – particularly the near-total use of fossil diesel fuel by the largest "heavy-heavy duty vehicles (HHDVs) – has many major adverse environmental consequences, with high corresponding economic costs. HHDVs emit disproportionately high levels of smog-causing pollutants that cause millions of Americans to regularly breathe unhealthful air. They emit high levels of toxic air contaminants (TACs) such as cancer-causing diesel particulate matter (DPM); this disproportionately impacts minority populations living in economically disadvantaged communities, which are often located adjacent to freeways or within areas of high diesel engine activity. Finally, HHDVs are also major emitters of greenhouse gases (GHGs), which cause global climate change.

Under the federal Clean Air Act, air quality officials in areas that don't meet health-based National Ambient Air Quality Standards (NAAQS) must develop and implement emissions-reduction strategies that demonstrate how attainment will be achieved, as expeditiously as possible. The greatest ongoing air quality challenge is to attain NAAQS for ozone and fine particulate matter ("$PM_{2.5}$ ") in our nation's most-polluted air sheds; these include California's South Coast and Central Valley air basins, the greater Houston area, and much of the Boston-Washington corridor. The key to achieve NAAQS for both ozone and $PM_{2.5}$ is to aggressively control oxides of nitrogen ("NOx") emissions from HHDVs. This must be done while also controlling other key pollutants, including GHGs and TACs.

2.2. The Call for Extremely Low-Emission HDVs Using Renewable Fuels

Over the last two decades, America has made major advancements to reduce on-road HDV emissions of NOx, DPM, other TACs, and GHGs. Solid progress has been made to phase in lower emission diesel trucks

[1] Online at at: http://www.arb.ca.gov/fuels/multimedia/meetings/renewabledieselstaffreport_nov2013.pdf.

and cleaner, alternative fuels to power a wide array of HDV types. Despite these important advancements, faster, far-greater progress is required. To meet health and environmental goals, America's heavy-duty transportation sector needs systematic transformation to the cleanest-available HDV technologies and fuels, as soon as they are developed and commercialized. In areas with the most severe air quality problems – such as southern and central California, and the greater Houston area – restoration of healthy air quality will require near-term, rapid phase-in of HDVs that provide zero-emission or near-zero-emission levels of NOx.

Key Related Policy Goals Involving Heavy-Duty Vehicles

Consumption of energy, creation of local air pollution, and emissions of GHGs that exacerbate global climate change are all closely related in today's U.S. HDV sector. There are many federal, state and local policies converging in this nexus that are collectively helping to drive America's transition towards advanced, clean HDV technology. Examples of key interrelated objectives involving the HDV transportation sector include the following:

- Reduce regulated pollutants (e.g. NOx) to attain National Ambient Air Quality Standards
- Reduce usage of petroleum-based diesel fuel
- Increase production and use of low-carbon renewable fuels
- Increase fuel economy of / reduce GHG emissions from HDVs
- Reduce upstream leakage of emissions of methane (a GHG and Short-Lived Climate Pollutant)
- Reduce emissions of black carbon (a Short-Lived Climate Pollutant)
- Replace, refuel, retrofit or repower in-use HDVs that pre-date state-of-the-art emission controls

California has the nation's most-aggressive goals to address these types of energy and environmental policy issues. The California Air Resources Board (CARB) has determined that the State must rapidly transition to vehicles that provide "zero-emissions everywhere feasible, and near-zero emissions using renewable fuels everywhere else." To meet this daunting requirement, CARB and other state transportation authorities have laid out a roadmap designed to widely deploy zero- and near-zero-emissions HDVs, especially in the most-impactful HHDV applications like on-road goods movement trucking.

Four Leading Fuel-Technology Pathways

Four unique fuel-technology combinations currently hold the most promise to successfully transform America's HDV transportation sector to zero and near-zero emissions using low-carbon non-petroleum fuels. These are: two types of low-emission internal combustion engines (fueled by RD or renewable natural gas); and two types of electric-drive systems (powered by batteries or hydrogen fuel cells). Each of these HDV pathways offers unique opportunity and challenges regarding their potential to help transform America's on-road HDV fleet. Over the long term (several decades), it is likely that all four of these HDV architectures will contribute to meeting air quality and climate change goals.

However, the actual role that each will ultimately play largely depends on how soon and to what degree they can be commercially deployed on a wide scale, especially in high-impact HHDV applications. The essential need is for zero- and/or near-zero-emission technologies and fuels to deeply penetrate into the urban HDV and on-road transportation sector in fewer than 10 years. As air quality regulators have widely recognized, early deployment is needed for hundreds of thousands of HDVs (especially HHDVs) using the cleanest available fuel-technology platforms. Lesser deployments will be insufficient in many U.S. cities to achieve health-based NAAQS, or drive down GHG emissions from the transportation sector as needed to mitigate global climate change.

The table below briefly describes each of the four leading HDV fuel-technology pathways, differentiated by their technology and fuel type, emissions profiles, and estimated timeline for initial commercial deployment to power significant numbers of on-road HDVs. As summarized below (and further documented in this White Paper), the RD / advanced diesel engine pathway and strategy (green dotted lines) provides an essential way for air quality regulators to immediately begin broadly providing low NOx and GHG emissions in high-impact HDV sectors.

Table 1. The RD / advanced diesel engine pathway provides immediate major GHG reductions for all HDVs

Prime Mover Technology	Assumed Fuel / Energy Source	Proven Regulated Emissions Profile (Direct HDV Emissions)	Proven GHG Emissions Profile	Timeline for Broad Deployment in High-Impact Heavy-Heavy-Duty Vehicles
Low-NOx Diesel Internal Combustion Engine (possible hybridization with electric drive, plug-in capability)	**Renewable Diesel** (increasing blends with fossil diesel)	**Baseline:** provides NOx and other emissions reductions for in-use HDVs; helps enable very-low NOx HDVs	**Extremely Low:** RD has an excellent combination of low carbon intensity fuel / high engine efficiency	**Immediate** for all in-use and new diesel engines
Low-NOx Natural Gas Internal Combustion Engine (possible hybridization with electric drive, plug-in capability)	**Renewable Natural Gas** (increasing blends with fossil gas)	**Near-Zero-Emission:** engine(s) certified to 90% below existing (2010) federal -NOx standard	**Extremely Low:** ultra-low (some negative) carbon intensity fuel options / good engine efficiency	**Immediate** for 9 liter HDV applications (trucking, refuse, transit); **2018** for HHDV 12L applications
Battery Electric Drive (possible hybridization with range extending fuel cell, other options)	**Grid Electricity** (increasing percentages made from renewables)	**Zero Emission:** meets CARB's definition (no direct-vehicle emissions)	**Very Low:** excellent combination of low carbon intensity fuel / very high drivetrain efficiency	**10 to 20 Years** in HHDV applications; **Immediate** for use in short-range MHDV and transit applications
Fuel Cell Electric Drive (likely hybridization with batteries for regenerative braking and peak power)	**Hydrogen** (increasing percentages made from renewables)	**Zero Emission:** meets CARB's definition (no direct-vehicle emissions)	**Very Low:** excellent combination of low carbon intensity fuel / very high drivetrain efficiency	**10 to 20 Years** in HHDV applications; **Potentially Near-Term** for use in short-range MHDV and transit applications

3. The Promise and Potential of Renewable Diesel

3.1. General Properties

Renewable diesel (RD) is an emerging “drop-in” HDV transportation fuel that is chemically and structurally “almost identical” to conventional diesel fuel. Transportation fuels in the U.S. must meet motor vehicle fuel specifications set by agencies like CARB and EPA. RD meets the same standards and specifications as conventional diesel for aromatics, sulfur, lubricity, and other key chemical or physical properties encumbered under ASTM[2] International Standard D975-12a.[3] This means that RD can be blended with conventional diesel “in any amount and used with existing infrastructure and diesel engines.” As stated by CARB, RD “*should be treated no differently”* than conventional diesel that is legally sold in California.[4] EPA, which generally refers to “biomass-based diesel,” has also approved RD as a replacement for conventional diesel.

It is important to note that RD is not biodiesel. RD uses similar feedstocks, but has different processing methods from biodiesel, and includes different chemical components. For example, RD is free of the ester compounds found in fatty acid methyl ester (FAME) biodiesel, and it has a much lower aromatic content.[5] High-level blends of RD, including 100 percent (RD100), can be used in existing heavy-duty diesel engines without modification. By comparison, heavy-duty engine manufacturers limit the blend percentage of biodiesel that can be used in their engines. Biodiesel blends up to B20 have been sanctioned by most heavy-duty engine OEMs; this was enabled by adoption of ASTM standard D7467.[6] Typically, OEMs impose restrictions on biodiesel blends over this percentage by voiding the customer’s new engine warranty, if it can be demonstrated that damage occurred due to a higher-level biodiesel blend.

Perhaps the most important difference from biodiesel is that RD decreases NOx emissions when used in new or in-use HDVs. As described elsewhere in this paper, this makes RD a highly valuable tool in the toolkit of air quality regulators.

3.2. Advantages, Uses and Acceptance by Heavy-Duty Engine / Vehicle Manufacturers

RD offers very significant advantages compared to both conventional diesel and biodiesel fuel. As noted, it is directly usable in existing diesel-powered vehicles, with no engine modifications required even for RD100. RD has a high cetane number[7] and other good qualities for compression-ignition engines, which enable it to provide similar or better vehicle performance compared to conventional ultra-low sulfur diesel (ULSD). It is a low-carbon-intensity fuel that can help reduce “engine-out” emissions of criteria pollutants and GHGs (see

[2] ASTM, formerly the American Society for Testing and Materials, develops international standards for materials, products, systems, and services used in construction, manufacturing, and transportation.
[3] California Environmental Protection Agency, “Staff Report: Multimedia Evaluation of Renewable Diesel,” prepared by the Multimedia Working Group, May 2015, http://www.arb.ca.gov/fuels/diesel/altdiesel/20150521RD_StaffReport.pdf.
[4] California Air Resources Board and State Water Resources Control Board, “Renewable Diesel Should Be Treated the Same as Conventional Diesel,” joint letter to various industry “stakeholders,” July 31, 2013.
[5] California Environmental Protection Agency, “Staff Report: Multimedia Evaluation of Renewable Diesel,” prepared by the Multimedia Working Group, May 2015, http://www.arb.ca.gov/fuels/diesel/altdiesel/20150521RD_StaffReport.pdf.
[6] DieselNet.com, “Compatibility of Biodiesel with Petroleum Diesel Engines,” accessed online at https://www.dieselnet.com/tech/fuel_biodiesel_comp.php.
[7] Cetane number refers to the relative ranking of a fuel’s auto-ignition characteristics for use in compression ignition (diesel) engines. Fuels with a high cetane number readily auto-ignite; this is essential for diesel engines.

below). Moreover, RD's near-zero sulfur content enables the use of advanced emission control devices. It can be produced using existing oil refinery capacity; thus, extensive new production facilities will not be required for expanded RD use.

The fact that pure (100%) RD is a drop-in, market-ready replacement for petroleum-based diesel has been formally corroborated by at least two major manufacturers of heavy-duty engines and trucks. Volvo Trucks North America conducted truck and engine testing on RD, and announced in 2015 that it has approved use of RD in all of its proprietary engines. Volvo indicated there is "no risk" that end users will lose their warranty coverage on any of their heavy-duty truck and engine combinations as the result of using RD.[8] Following "extensive truck and engine testing," Mack Trucks (owned by Volvo) has also "signed off" on the use of renewable diesel fuel in all its diesel engines.[9] Cummins Engine Company is now completing its own thorough review of RD as a drop-in substitute for fossil diesel in its engines. To date, there is no reason to believe that Cummins won't also give full approval for the use of RD. The Engine Manufacturers Association (EMA) appears to be awaiting for Cummins to release its findings before making a formal statement about RD use as a drop-in substitute for conventional diesel fuel.

3.3. Production, Feedstock and Supply

Various biomass-to-liquid processes are used to produce RD. The most common process is to upgrade conventional biodiesel (or fatty acid methyl esters, FAME) via hydrogenation, using existing hydro-treatment processing equipment. The resulting fuel contains pure hydrocarbons and paraffinic compounds, with very low aromatics.

Neste (formerly Neste Oil) is currently the world's largest RD producer for American markets. Approximately 325 to 400 million gallons of RD were supplied to U.S. markets in 2014, most of which was imported by Neste.[10,11] Neste's NExBTL process is capable of using multiple feedstock that include palm oil, palm fatty acid distillate (PFAD; a byproduct from the physical refining of palm oil), tallow (i.e., rendered animal fat), and used cooking oil. Currently, the greatest U.S. demand for RD is in California, which has received about one third of the U.S. supply (imported and domestic), most of which has been imported from Neste's Singapore plant and produced from tallow[12] feedstock. There are at least two facilities that currently produce RD at commercial scale <u>within</u> the U.S., but there are no known RD shipments to California from these plants. It's currently uncertain if these facilities will choose to deliver product to the California market.

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[8] Volvo Trucks North America, "Volvo Trucks Approves Renewable Diesel Fuel for Proprietary Engines," press release, December 9, 2015.

[9] Mack Trucks, "Mack Trucks Green-Lights Renewable Diesel for Use in Mack Engines," http://www.macktrucks.com/community/mack-news/2016/mack-trucks-green-lights-renewable-diesel-fuel/.

[10] CARB, Low Carbon Fuel Standard, "Appendix B, Development of Illustrative Compliance Scenarios and Evaluation of Potential Compliance Scenarios," 2015.

[11] U.S. EPA, Renewable Fuel Standard Program: Standards for 2014, 2015 and 2016 and Biomass-Based Diesel Volume for 2017; Proposed Rule; 40 CFR Part 80 No. 111, June 10, 2015.

[12] Tallow is animal fat derived from waste at a meat processing plant. Rendering produces two types: edible and inedible tallow. Edible tallow is used by the food industry and most of the inedible tallow is currently used as a supplement in animal feed, but can also be a feedstock for RD.

3.4. Expanding End Users, Constrained Supply

As noted, California currently leads the U.S. in the use of RD as a HDV transportation fuel. In 2014, 113 million gallons of RD were used to generate credits in the California LCFS program. This constituted roughly 15 percent of all 2014 credits under the LCFS. Demand for RD is expected to grow in California and other states, due to the previously noted environmental and economic drivers.

Examples of major HDV fleets adopting the use of RD include the following:

- In July 2015, United Parcel Services (UPS) announced that it will buy as much as 46 million gallons of RD over the next three years. UPS has set a goal to displace 12 percent of its petroleum-based fuels in its ground fleet by 2017. The renewable diesel that UPS will purchase will come from three different pathways: 1) tallow, 2) vegetable oil and fats, and 3) algae-derived oil. UPS executives indicate that performance will be "as good or even better" than traditional diesel.[13] However, UPS executives have expressed strong concern that they "can't get enough" RD to meet their fleet's needs (see call-out quote).

> **UPS (on ordering 46 million RD gallons)**
>
> *We believe that this could be a game-changer for the industry, but the speed of change will depend on availability. The bad news is on the supply side. We can't get enough of it. We're hoping that (UPS's order) encourages bio-refineries and suppliers of (RD) feed stock.*
>
> -**Carlton Rose, UPS**, President of Global Fleet Maintenance & Engineering, ACT EXPO 2016, Long Beach, CA

- In mid-2015, the City of San Francisco announced that its municipal HDV fleet will switch from petroleum diesel to RD by early 2016. Reportedly, all 53 diesel fueling sites are switching to 99 percent RD (RD99), with the intent for nearly 2,000 HDVs to operate on it. This will require an estimated 4.9 million gallons of RD per year.[14]

- The northern California cities of Walnut Creek and Oakland have also made similar announcements about switching their City-owned HDVs over to RD. Oakland's HDV fleet of 250 diesel vehicles will use a reported 230,000 gallons of RD each year.[15]

- In December 2015, the California Department of General Services issued a memo stipulating that California agencies "shall purchase state-contracted renewable diesel fuel, in lieu of conventional diesel and biodiesel fuels, when making bulk purchases of fuel for diesel powered vehicles and/or equipment." Reportedly, at least 80 percent of the RD will be "NexDiesel" supplied by Golden State Petroleum, which uses Neste as its bulk supplier.[16]

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[13] New York Times, "UPS Agrees to Buy 46 Million Gallons of Renewable Diesel," July 29, 2015, accessed online at http://www.nytimes.com/2015/07/30/business/ups-agrees-to-buy-46-million-gallons-of-renewable-diesel.html?_r=0.
[14] San Francisco Examiner, "City fleet to adopt use of renewable diesel fuel," July 21, 2015.
[15] Government Fleet, "Oakland Moves to Renewable Diesel for City Fleet," October 2016, http://www.government-fleet.com/news/story/2015/10/third-calif-fleet-switches-to-renewable-diesel.aspx
[16] Fleets and Fuels, "Cal DGS Requires Renewable Diesel," December 11, 2015.

- In early 2015, Propel Fuels began selling RD at 18 fueling stations in California. Propel is California's self-proclaimed "largest retailer of low-carbon fuels. As of late 2015, Propel is selling its "Diesel HPR" (*High Performance Renewable*) at 31 stations in northern and southern California. Propel's "Diesel HPR" (*High Performance Renewable*) fuel consists of 98 percent RD (supplied by Neste, from the NEXBTL process) blended with 2 percent CARB diesel.

- The California Energy Commission has just awarded $11.2 million in funds from the Alternative and Renewable Fuel and Vehicle Technology Program (ARFVTP) to add approximately 27 MGPY of additional RD production capacity.[17] UrbanX has been awarded a $5 million grant under this program for the development of its RD production biorefinery.

- The Oregon Department of Energy is working with "public entities across the state" to "tap into the emerging renewable diesel market." One such entity, thee Eugene Water & Electric Board, has switched its fleet to RD from biodiesel, and now uses about 6,100 gallons of RD per month. Fleet managers note that the use of RD has resulted in less-frequent need to undergo regeneration (by manual cleaning) of the diesel particulate filters on their HDV fleet.[18]

3.5. Criteria Pollutant Emissions

CARB has performed in-house testing and also contracted with the University of California, Riverside to evaluate tailpipe emissions of HDVs using RD. This program included chassis dynamometer testing of on-road HDVs, as well as engine dynamometer testing of on- and off-road engines. Various test engines, vehicles, cycles and RD blends were used in these evaluations. CARB concluded the following:

> *"In general, this study found that most emissions from renewable diesel are reduced (relative to) diesel fuel meeting ARB motor vehicle fuel specifications (CARB diesel), including particulate matter (PM), oxides of nitrogen (NOx), carbon monoxide (CO), carbon dioxide (CO_2), total hydrocarbons (THC), and most toxic species."*

NOx is the key criteria pollutant that must be dramatically reduced to attain NAAQS in "extreme" ozone areas like California's SCAB and SJVAB. CARB found that 100 percent RD "generally" decreases NOx by roughly 10 percent, and thus it "could be expected to improve ground level ozone" compared to baseline CARB diesel fuel. CARB also noted that RD reduces PM emissions by about 30 percent (including carcinogenic diesel PM). When used in newer engines/vehicles (e.g., 2010 compliant diesel engines) with state-of-the-art emissions controls, these benefits are likely to be reduced significantly.[19] However, RD can provide major and immediate NOx reductions when substituted for conventional diesel in millions of heavy-duty off-road vehicles and equipment types. Perhaps most importantly, RD is a critical part of the

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[17] California Energy Commission, Alternative and Renewable Fuel and Vehicle Technology Program Project Funding Summary through April 15, 2015, accessed online, http://steps.ucdavis.edu/files/09-11-2015-Compendium-Narrative-updated-4.15.15.pdf.

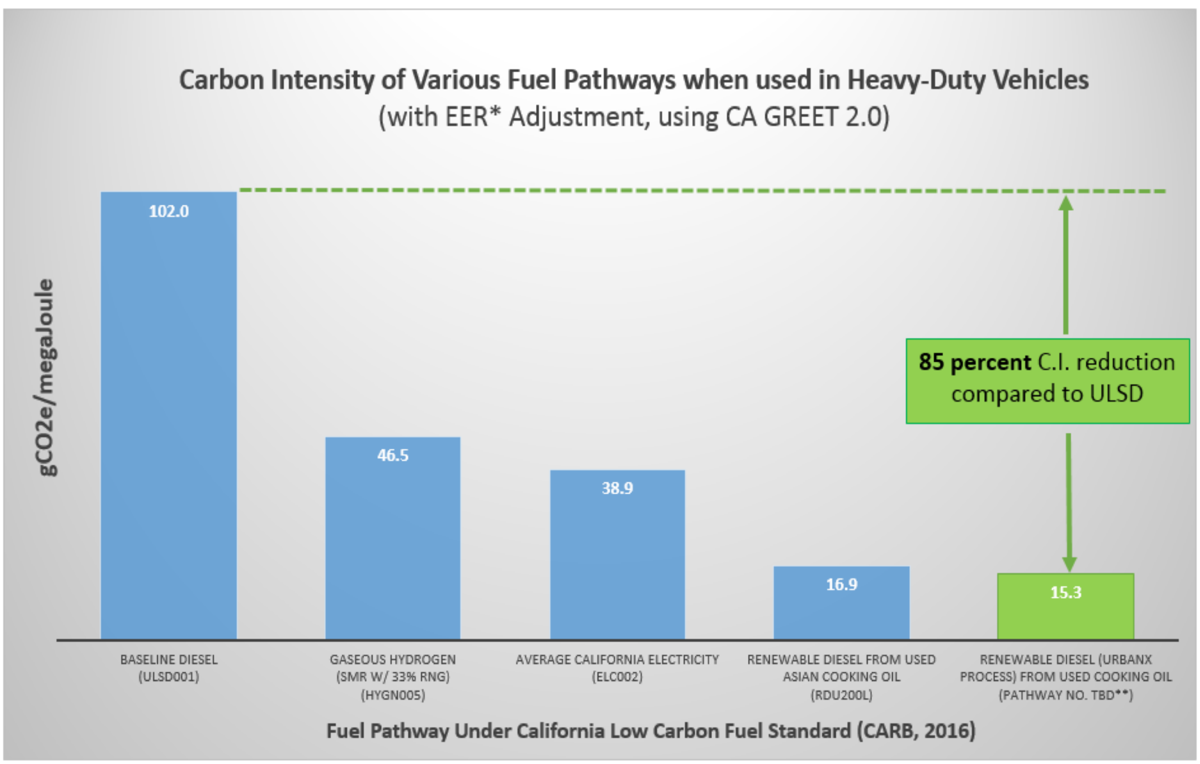
[18] NGTNews, "Eugene Water & Electric Board Touts Switch to Renewable Diesel," January 18, 2016, http://ngtnews.com/eugene-water-electric-board-touts-switch-to-renewable-diesel/?utm_medium=email&utm_source=LNH+01-19-2016&utm_campaign=NGT+Latest+News+Headlines.

[19] CARB Staff Report, Multimedia Evaluation of Renewable Diesel, Prepared by Multimedia Working Group, November 2013. Available online: http://www.arb.ca.gov/fuels/multimedia/meetings/renewabledieselstaffreport_nov2013.pdf

pathway that will enable heavy-duty engine manufacturers to develop a new generation of near-zero-NOx diesel engines.

3.6. GHG Emissions and Carbon Intensity

When used to displace conventional diesel as an HDV fuel, RD can provide major reductions in full-fuel-cycle GHG emissions. Recently, CARB applied its latest "CA-GREET" model to calculate full fuel cycle carbon intensity (CI) scores for "representative" RD fuel pathways (i.e., they are not based on any individual producer's parameters). CARB's analysis indicates that five different *certified* RD fuel pathways have CI scores that range from 51 to 83 percent lower (i.e., less carbon intense) than the baseline CARB diesel fuel. Currently, tallow is the feedstock for most RD used in California; it has a preliminary CI score under the new model that is 72 percent lower than CARB diesel.[20] The Asian cooking oil pathway (RDU200L) is 83 percent lower. As shown in Figure 1, UrbanX's RD pathway is expected to be 85 percent less carbon intense than ULSD. Compared to 33 percent renewable hydrogen and the average California electricity mix, the carbon intensity of UrbanX's RD will be approximately 67 and 61 percent lower, respectively.



*EER = "Energy Economy Ratio", this is an adjustment for efficiency of the heavy-duty vehicle type that uses the indicated fuel.
**The carbon intensity value shown for UrbanX's RD process is based on preliminary estimates; this pathway is under development for certification by CARB.

Figure 1. Carbon intensity values of UrbanX renewable diesel vs. baseline diesel (ULSD), hydrogen and electricity

[20] CARB, "LCFS Illustrative Fuel Pathway Carbon Intensity Determined Using CA-GREET 2.0," 9/17/2015, online at http://steps.ucdavis.edu/files/09-17-2015-Table-for-UCDavis_LCFS-Illustrative-CIs_FINAL.pdf. Total CI scores include direct and indirect contributions.

3.7. Concurrence from Air Quality Regulators and Energy Agencies

Recognizing the critical role that alternatives to conventional diesel must play in California, CARB has adopted a regulation governing alternative diesel fuels (ADF). RD is the most common ADF used in California. CARB's ADF regulation puts in place a three-step process beginning in 2016, designed to help cleaner diesel substitutes like RD flourish in the market. This is very important, because CARB has concluded that "combustion technology will continue to dominate" the on-road HDV sector for at least another 15 years. In fact, CARB has found that heavy-duty trucks with advanced low-emission engines are "the most viable approach" to meet California's mid- and longer-term goals for attainment of health-based ambient air quality standards. CARB has noted that it is technically and economically feasible to deploy approximately 400,000 near-zero-emission HDVs by 2030, and this "large-scale deployment" of low-NOx, very-low-PM goods movement trucks "will provide the largest health benefit of any single new strategy" under consideration by California. To simultaneously meet GHG and petroleum-use-reduction targets, CARB will target that approximately 55 percent of fuel demand for these trucks will be met with RD or other renewable fuel types such as biomethane. CARB concludes that "deployment of 350,000 electric trucks over the next 15 years would require technology development and cost that are well beyond what will be needed to deploy low-NOx (internal combustion engine) trucks."

As part of the 2016 State Implementation Plan (SIP), CARB is developing a requirement that "low-emission diesel" will comprise "a steadily increasing percent of the ARB diesel pool. "The proposed measure will be phased-in with a gradual implementation strategy that starts in the Los Angeles area, and subsequently expands statewide. CARB's fuel specification will include an aromatics content that is less than one percent, with virtually no sulfur, and a maximum blendstock carbon intensity of 30-60 gCO2e/MJ. This proposed measure will likely require incremental progress towards 50 percent of all on- and off-road diesel sold in California by 2031 meeting this standard.[21] According to CARB staff, most of this demand for so-called "low emission diesel" will be met by RD.[22] This constitutes an annual demand for RD in the billions of gallons for California transportation markets alone, within the next 15 years.

CARB's SIP is urgently geared towards attaining ambient air quality standards for ozone by 2023 in the South Coast and Central (San Joaquin) Valley areas, which both face extremely tough challenges to drastically reduce ozone. Over just seven years, these air basins require very large NOx reductions from high-impact heavy-heavy-duty goods movement trucks and other HHDVs. At the same time, state and local goals for GHG reductions must also be met. The South Coast Air Quality Management District (SCAQMD) has identified "early deployment of zero and near-zero-emission technologies" as an essential strategy for its 2016 blueprint for clean air:

> *"(SCAQMD) will strongly rely on a transition to zero- and near-zero emission technologies in the mobile source sector including automobiles, transit buses, medium- and heavy-duty trucks, and off-road applications to meet the air quality standards. The plan will focus on existing commercialized*

[21] California Air Resources Board, Proposed Strategy for the State Implementation Plan, May 17, 2016, https://www.arb.ca.gov/planning/sip/2016sip/2016statesip.pdf.
22 California Air Resouces Board, 2016 SIP Public Workshop, September 1, 2016, https://www.arb.ca.gov/planning/sip/2016sip/090116wkshp_slides.pdf

technologies and energy sources and newer technologies that are nearing commercialization based on demonstration programs and limited test markets, including their supporting infrastructure."[23]

3.8. Current RD Cost and Price

Like other renewable fuels and energy sources, it currently costs more to produce RD compared to conventional diesel fuel. However, retailers are able to sell RD at a price per gallon that is equal to or even less than conventional diesel. For example, Propel Fuels currently sells RD at 31 stations in California at a per-gallon price that is slightly below diesel.[24] This is largely possible because producers and end users of RD are able to take advantage of monetary incentives provided under the California Low Carbon Fuel Standard (LCFS) and the federal Renewable Fuel Standard (RFS). When used as a transportation fuel, RD can generate lucrative credits under both programs that make it a very affordable, ultra-low-GHG alternative to conventional diesel.

3.9. Supply Constraints and Potential for Expansion of U.S. Production Capacity

Supply availability is the most-significant constraint for expanding RD use into HDV transportation markets. This is partly linked to feedstock issues and competition from other markets. As noted, animal rendering (tallow) is currently the feedstock for most RD used in the U.S. According to CARB, "additional availability of tallow feedstocks are not certain, as most of the U.S. supply of tallow may not be available to RD production, and international tallow is already being drawn to the U.S. in large amounts." However, CARB also notes that "RD can be produced from any fatty acid feedstock."[25] As described in the next section, UrbanX's special process to make RD from used cooking oil offers a variety of critical advantages.

This is one reason that regulators and market observers—especially in California—are increasingly optimistic about RD's potential to become a mainstream replacement for conventional diesel fuel. CARB has developed an illustrative compliance scenario estimating low-, mid-, and high-growth projections for total U.S. RD production capacity. As shown in Table 2, projections for total U.S. capacity range from 690 to 1,290 million gallons per year (MGPY).[26] CARB assumes that 400 MGPY of this national RD production in 2020 will be available for use in California.

Table 2. Projected U.S. renewable diesel production capacity in 2020 (CARB, 2015)

Current Capacity **(MGPY)**	Announced Capacity **(MGPY)**	CARB Growth Scenarios	By 2020 (MGPY)	
			Projected Additional Capacity	Total
212	277	Low Growth	200	689
		Mid Growth	400	889
		High Growth	800	1,289

[23] South Coast Air Quality Management District, "Blueprint for Clean Air," 2016 AQMP White Paper, October 2015, http://www.aqmd.gov/docs/default-source/Agendas/aqmp/white-paper-working-groups/wp-blueprint-final.pdf?sfvrsn=2.
[24] From Propel Fuels website, and a personal communication to GNA after calling the Propel Fuels Customer Service hotline.
[25] CARB Staff Report, Multimedia Evaluation of Renewable Diesel, Prepared by Multimedia Working Group, November 2013. Available online: http://www.arb.ca.gov/fuels/multimedia/meetings/renewabledieselstaffreport_nov2013.pdf
[26] CARB, Appendix B, Development of Illustrative Compliance Scenarios and Evaluation of Potential Compliance Scenarios, 2015.

Lux Research recently prepared a report[27] assessing the outlook for RD and other biofuels for the 2018 timeframe. The report cites the U.S. and Brazil as being the "biggest emerging production center for biofuels" such as RD. Lux Research estimated that RD will make up 18 percent (nearly 11 billion gallons per year) of the world's total biofuel production in 2018. Using its database of more than 1,800 global biofuel production facilities, Lux projected capacity expansion for RD in the U.S. over the next three years to be 279 MGPY. An additional 69 MGPY of new added renewable diesel capacity is expected for Canada. This makes the total projected added RD capacity in North America to be about 348 MGPY. These figures do not reflect the existing RD in the U.S. and Canada.[28]

4. The UrbanX Advantage for Producing RD in America

UrbanX is the exclusive licensee of the Chevron Lummus Global IsoConversion RD manufacturing technology. This has unique and distinct advantages compared to other domestic U.S. biofuel production processes. UrbanX's exclusive technology offers several key sustainability benefits for domestic production in states that have immediate demand for its use, such as California. UrbanX's proposed facility will be built at an idled petroleum refinery in Long Beach, California, and will serve as the only biorefinery in America that can process and convert 100 percent high-acid, waste-grade Fat, Oil and Grease to Renewable Diesel that is chemically equivalent to its petroleum counterpart. This is high-acid rendered grease is separated from grease traps emulsion waste and recovered from water treatment plants. Disposing of brown grease presents major challenges for wastewater treatment plants, as well as the waste system overall. Most of it is currently exported to other states for further blending and processing, thereby increasing local GHG emissions. The rest of California's biodiesel refineries are limited to processing low-acid vegetable oils, which consist of virgin oils such as corn or soybean; used cooking oil; technical grade beef tallow; or palm oil. As noted above, although other petroleum suppliers in California distribute RD, this is currently sourced from outside California, and the overwhelming majority of RD distributed in California is sourced from outside of the United States. This means that the greenhouse gas benefits of UrbanX's California-produced fuel can exceed other current sources of RD in the marketplace. For all of these reasons, UrbanX is seeking to raise an equity round of capital, which will be used to retrofit the existing infrastructure at the identified idled petroleum refinery, install the new exclusively licensed Chevron Lummus IsoConversion process technology and begin RD production to serve California's growing demand for 100% drop-in renewable fuel.

In addition to the sustainability impacts from the fuel itself, UrbanX has invested heavily in green manufacturing processes, including developing a proprietary water conservation process to reclaim grease trap wastewater for use as a steam boiler feed water. As a firm, UrbanX aims for vertical integration along its supply chain and the investment UrbanX has made in its ability to treat wastewater onsite has additional sustainability and economic benefits as well. Recently, UrbanX entered into an agreement with California Polytechnic University-Pomona at their Chino 1,000-acre ranch to support its livestock and dairy

[27] Lux Research, "Biofuels Outlook 2018: Highlighting Emerging Producers and Next-Generation Biofuels," press release, http://www.luxresearchinc.com/news-and-events/press-releases/read/biofuels-capacity-grow-61-bgy-2018.
[27] CARB, Draft Technology Assessment: Lower-NOx Heavy-Duty Diesel Engines," http://www.arb.ca.gov/msprog/tech/techreport/diesel_tech_report.pdf, September 2015.
[28] Victor Oh, Lux Research, personal communication to Jon Leonard of GNA, December 15, 2015.

farms through the use of pretreated water for irrigation purposes, produced from UrbanX's reclamation efforts from grease trap wastewater. The sustainability elements of the project ultimately reduce the Carbon Intensity (CI) of the finished RD fuel, which in turn increase the monetary value of the LCFS and RIN credits and positively impact bottom-line profitability.

5. Summary: Growing Demand for RD as a Ultra-Clean Heavy-Duty Vehicle Fuel

California intends to "implement statewide strategies that employ lower NOX combustion engines coupled with the use of renewable fuels."[29] This includes very significant plans to increase the volume of RD used in diesel engines, which by itself can provide significant reductions in criteria pollutants (including NOx) while delivering major GHG reductions. As heavy-duty engines with progressively lower NOx levels are commercialized, the combination of such engines and RD substituted for conventional diesel will offer compelling NOx and GHG benefits.

To fully achieve California's NOx-reduction goals—as necessary to attain ozone NAAQS in 2023 and 2032)—it will be necessary to rapidly phase-in very large numbers of HDVs that emit NOx at *near-zero* or *zero* levels. Heavy-duty diesel engines appear to be on the pathway to achieve these low NOx levels, and RD can play an important role in enabling this progress. California's draft Mobile Source Strategy makes it clear that CARB expects hundreds of thousands of low-NOx trucks using RD to be deployed in the state over the next two decades.

The major impediment to this plan, and achieving these essential societal benefits, is the lack of current domestic production for RD using cost-effective, environmentally sustainable feedstock.

UrbanX, with its vertically integrated feedstock network, exclusively licensed cost-effective technology—which includes a production guarantee from Chevron Lummus Global, and expressed demand for its upcoming RD production, is best positioned to become the leader in Renewable Diesel production on the west and will actively pursue idle petroleum refinery retrofit expansion opportunities up the coast to serve the ever-increasing demand for 100% drop-in fuel.