# Lower Carbon Intensity Pathways

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# About Matt Sheehan

Matt Sheehan is a Senior Consulting Engineer on the Fuels Products & Technology team at our Chevron Technology Center in Richmond, CA, a position he has held since 2019. His primary role is to set fuels product line strategy and provide subject matter expertise on fuel specifications and performance. Matt serves on the Coordinating Research Council (CRC) Board of Directors and the CRC Performance and Sustainable Mobility Committees. He is an active participant on the ASTM Main Committee and Subcommittee A where he also serves as section chair for Gasoline and Gasoline/Oxygenate Blends.

Previously, Matt served as Biofuels Technology Commercialization Manager in Chevron's Downstream Fuels and Products Strategy group, where he developed opportunities to integrate renewable fuels processing in Chevron's refineries. The resulting projects are enabling Chevron's compliance with California's Low Carbon Fuels Standard.

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## Section 2

# Chevron Lower Carbon Solutions

**“Our strategy is clear:**
Leverage our strengths
to deliver lower carbon energy
to a growing world.”

**Mike Wirth**
Chairman of the Board
and CEO of Chevron

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# Our Energy Transition strategy
## Advance a lower carbon future

### Lower carbon intensity of our operations

**Target**
35% carbon reduction in Upstream by 2028

**Maintain**
1st quartile performance in oil and gas GHG intensity

**Focus**
on methane, flaring and energy management

**Aim**
2050 net zero aspiration* for upstream Scope 1 & 2 emissions

### Grow lower carbon businesses

Renewable fuels & products


Hydrogen**

Carbon capture, utilization & storage

Offsets & emerging lower carbon opportunities

Chevron expects to triple our lower carbon capital versus prior guidance to over $10 billion between now and 2028:
**$2B in carbon reduction projects** and **$8B in low carbon investments**

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* Upstream emission intensity Scope 1 and 2 in $kgCO_2e$/BOE.Achieving the Upstream 2050 net zero aspiration will require continued partnership and progress in technology, policy, regulations, and offset markets.

**Chevron's approach to hydrogen envisions the use of green, blue, and gray hydrogen. See Climate Change Resilience Report pg 51.to learn more.

# Activating our renewable fuels strategy

## Gaseous Fuels

### RNG

**CalBio & Brightmark LLC Partnerships**
Partnered with CalBio and Brightmark for production of ~10,000 MMBTU/day of RNG from dairy farms. Farms are slated to come online through 2023. These partnerships amount to ~190,000 milking cow equivalents

### CNG

**CNG Fueling Network Joint Venture**
Formed a joint venture with Mercuria to own and operate American Natural Gas (ANG) and its network of 60 CNG stations

**Adopt-a-Port**
Partnering with Clean Energy to provide RNG to truck operators at the ports of LA and Long Beach

### Hydrogen

**Iwatani Partnership for 30 Stations**
Partnering with Iwatani to develop a fully integrated supply chain to build out 30 Retail Stations in CA

**Raven SR Investment**
Invested in waste-to-hydrogen steam/CO2 reforming company to secure renewable offtake and on-site H2 production

## Liquid Fuels

### Renewable Diesel & Biodiesel

**REG**
Acquisition of Renewable Energy Group adds manufacturing base and capabilities in renewable- and bio-diesel

**Ramping up retail offering**
In the US, >38% of our ULSD blends have some renewable content. RD sales have increased >30 vol% in 2021. We've successfully converted many CA Retail stations to R80B20 offering

**Offering B20 at terminals**
Offering B20 in California & Texas with more terminals on the horizon

### Equity Production Capacity

**Bunge Joint Venture**
Partnering with Bunge to develop lower carbon intensity feedstocks

**El Segundo DHT Conversion 2023**
Announced conversion of the diesel hydrotreater to 100% Renewable Production

**El Segundo FCC Coprocessing**
Became the 1st refinery in the US to ratably co-process bio-feedstock through an FCC to make gasoline, jet fuel and diesel. Partnered with Delta and Google to deliver sustainable aviation fuel.

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# How can we help reduce GHG impacts from Gasoline?

## Options for Lowering the Carbon Intensity of Gasoline

### Refinery Efficiency

Marginal Abatement Cost Curve (MACC) methodology is employed to systematically lower GHG emissions and costs.

### Ethanol

Ethanol is a widely used lower-carbon gasoline blend component with favorable octane properties.

### Lipids Processing

Lipids can be processed by today's refining infrastructure into drop-in hydrocarbon liquid products

### Biomass Feedstock

Cellulosic biomass and waste feedstocks can have lower carbon intensity scores

### Advanced ICE Technology

Fuels have a role in enabling advanced ICE technology that can help improve vehicle efficiency.

### Refinery CCUS

Carbon Capture, Use and Storage from sources at the refinery can lower the $CO_2$ impact of our manufacturing.

### $CO_2$ to fuels

Captured $CO_2$ can be converted to synthetic fuels, potentially produced with renewable hydrogen and electricity.

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1) This is not a comprehensive list. Additional technologies and pathways may be available.

## Section 3

# Refinery Processing of Lipids

**Multitude of processing and product options**

**Complexity can be an advantage**

**Robust process engineering design is critical**

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# Bringing Renewables to the Refinery

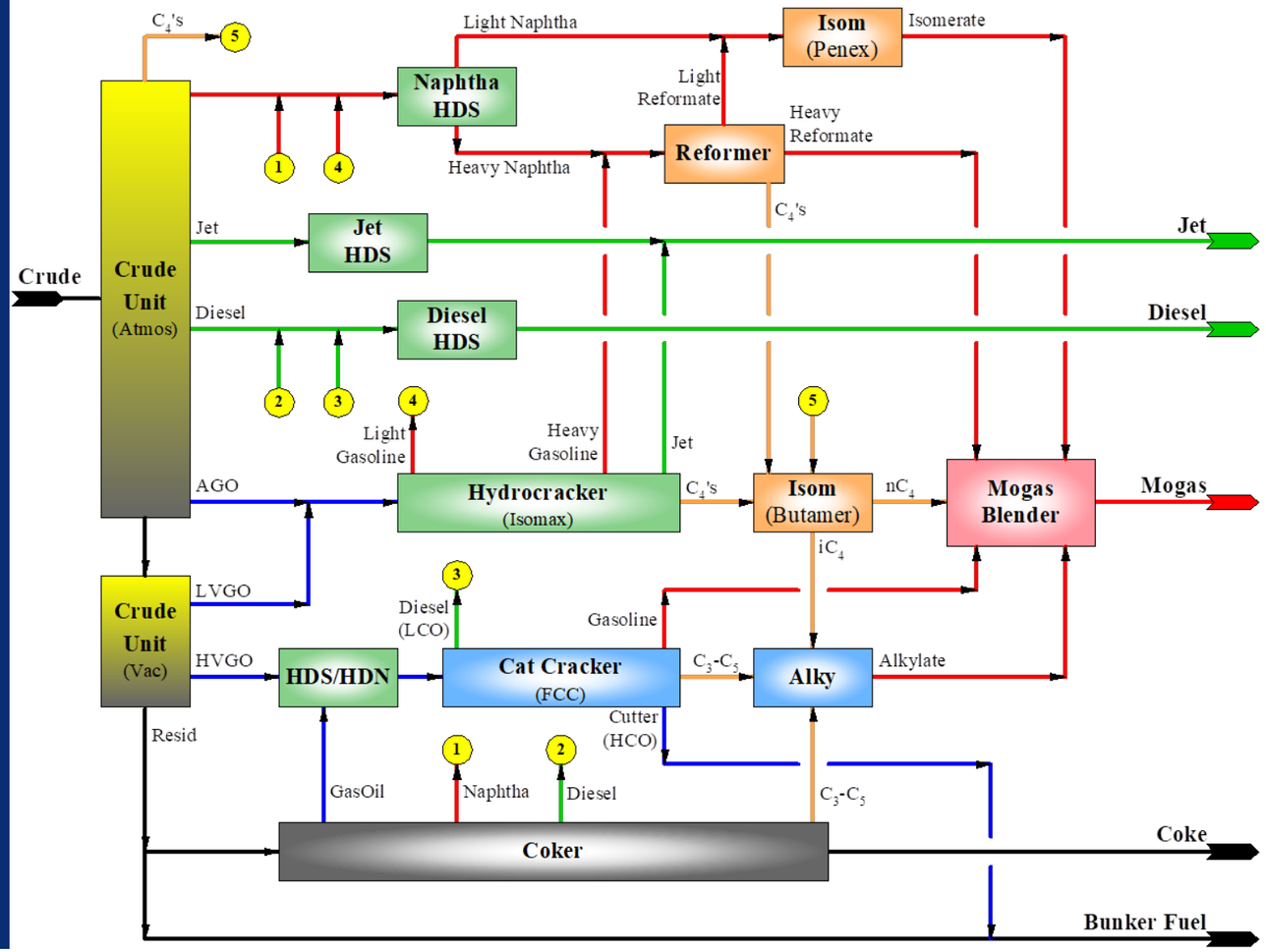
**Existing refinery infrastructure can be used to make renewable fuels:**

- Coprocessing or stand alone
- Renewable Diesel, Jet, Gasoline
- Reduce refinery's carbon intensity

**Challenges:**

- Each refinery is unique
- Refinery processing is optimized for crude slate and high-value product mix
- New infrastructure considerations for bio-oil ingress
- Regulatory pathways and renewable fuel credit validation process is complicated.
  - Can involve tracking molecules through multiple processes
  - C14 testing may be required

## Typical Refinery Process Diagram[1]

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1) Not representative of a specific refinery. Processes and layout vary between refineries.

# Lipids Process Engineering Considerations

**Catalytic Reaction**

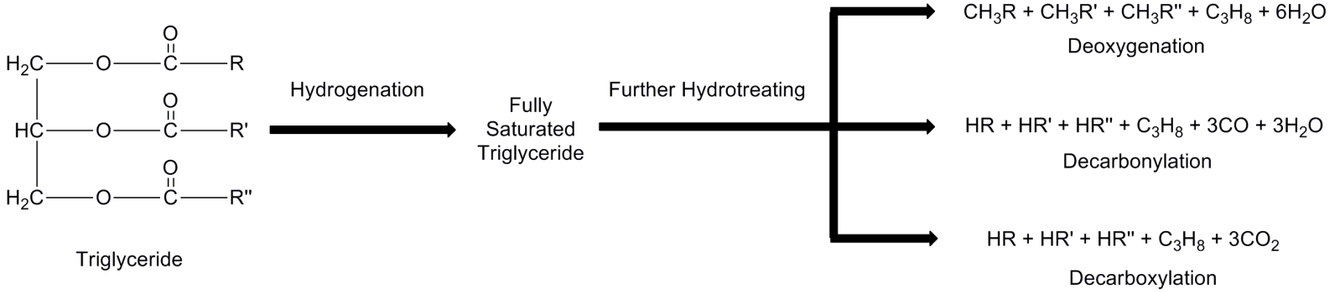
Catalyst Life

- Exothermic reaction
- Metals and other impurities

n-Paraffin products may require hydro-isomerization to improve cold flow properties

## Conversion Chemistry

Refinery processing saturates the bio-feedstock molecule, removes oxygen, and breaks the triglyceride molecule into three long chain paraffins.




Tradeoff between product yields and hydrogen requirements

**Process and equipment**

Process effluent water and/or CO2

- Hydraulics
- Metallurgy

Heat exchanger fouling

Hydrogen availability

Corrosion

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## Section 4

# Lipid Feedstocks

**Renewable feedstock demand is growing**

**Distillers Corn Oil use is on the rise**

**Different feedstocks have different material properties**

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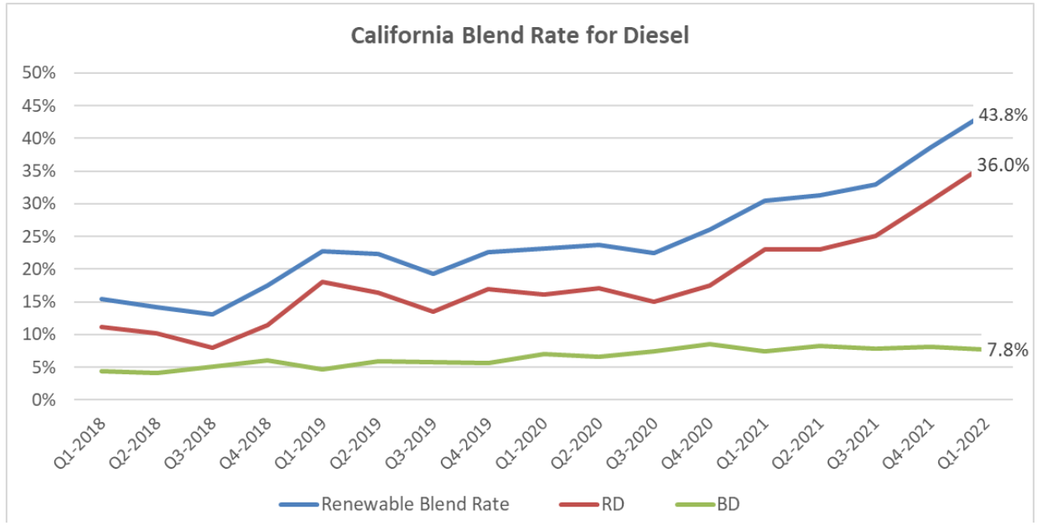
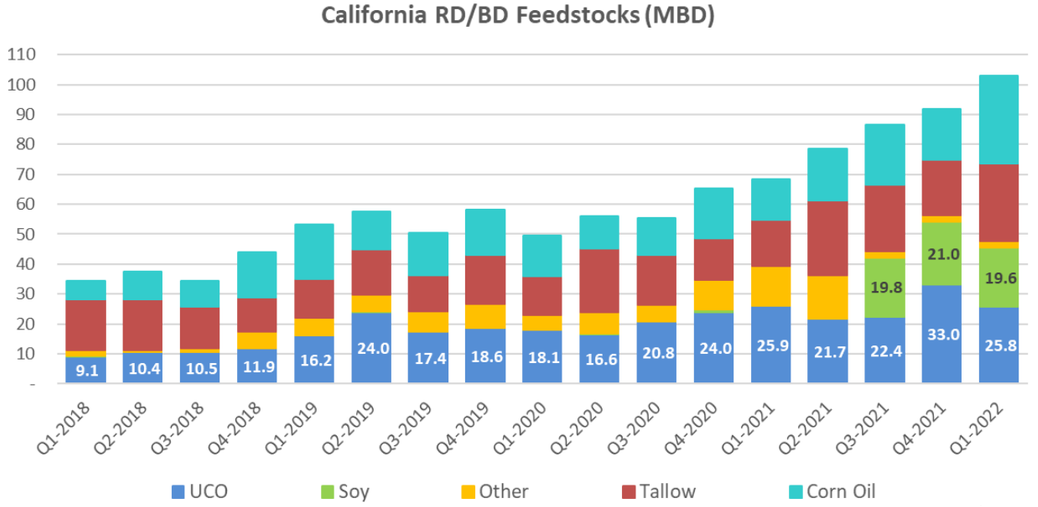
# California Renewable Feedstock Use

**From CARB Quarterly Report July 2022, in the 1st quarter of 2022:**

- Renewable blend rate increased to 43.8% of diesel volumes.
- Renewable diesel usage at a record high of 320 MM gallons.
- Renewable Diesel produced from corn oil increased to 76.7 MM gallons, up 53% from prior quarter
- Biodiesel produced from corn oil increased to 34.8 MM gallons, up 54% from prior quarter

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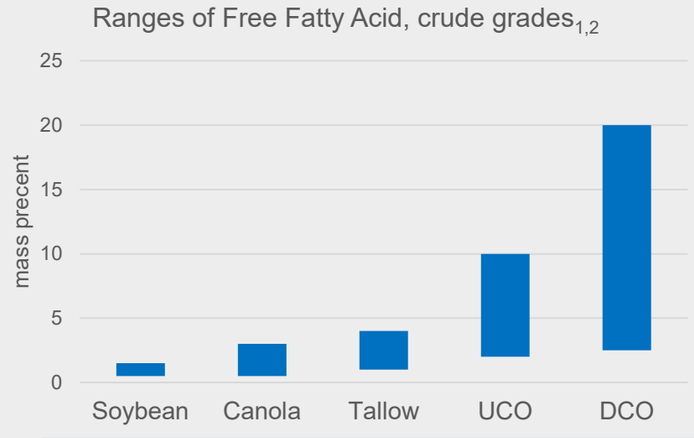
# Feedstock Impurities for Renewable Diesel Processing

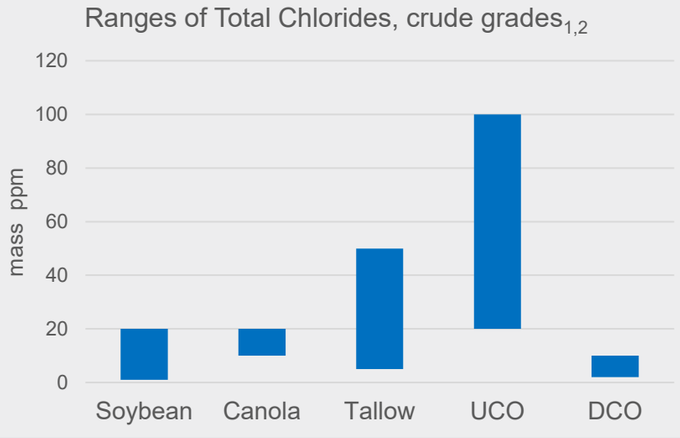
## Free Fatty Acids

Corrosion risk to equipment upstream of the reactor



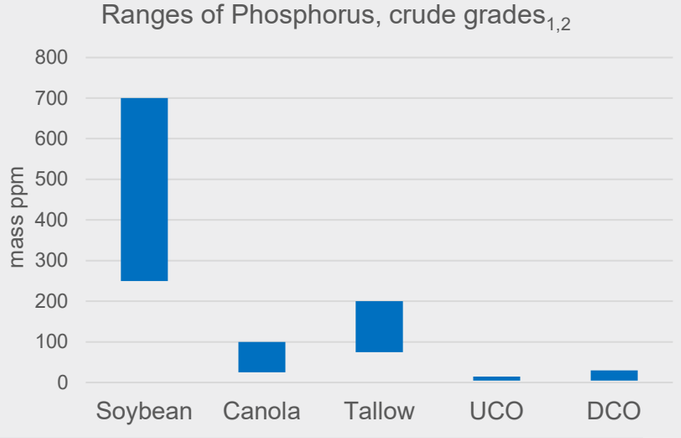

## Chlorides

Corrosion risk to equipment downstream of the reactor




## Metals

Catalyst deactivation risk from phosphorus, calcium, iron, magnesium, potassium and sodium.




Effects of Free Fatty Acids, Chlorides and Metals can be mitigated by process engineering design or by reducing their content in the feedstock[3].

Do not want solids, water or unsaponifiable.

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1) Ranges in charts are Chevron data from research samples collected between 2009 and 2020, are not representative of a particular supply source or grade.
2) Tallow and Canola data is from refined or partially refined samples
3) Processes and feedstock requirements vary for each plant

## Section 5

# Opportunities to Work Together

"No single company, industry or country will have all the answers, and we will need to work together. We are building and strengthening partnerships with those who have shared aspirations and where our combined strengths can have a tangible impact on delivering a lower carbon future."

**Barbara Burger**
**Vice President, Innovation and President, Technology Ventures (retired)**

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# We share the same interests

## common ground on the future of liquid fuels as a lower carbon solution

### Products & Feedstocks

Lower carbon intensity ethanol

Sustainable Aviation Fuels

Distillers Corn Oil

Cellulosic feedstocks

### Technology

Processing upgrades

Carbon Capture Use and Sequestration

ICE technology

Renewable Energy

### Policy & Regulation

Incentives for lower carbon intensity fuels

Level playing field for all vehicle and fuel technologies

Lifecycle Analysis, GREET

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# Learn more about Chevron's Lower Carbon Energy Future

## click on picture or use links

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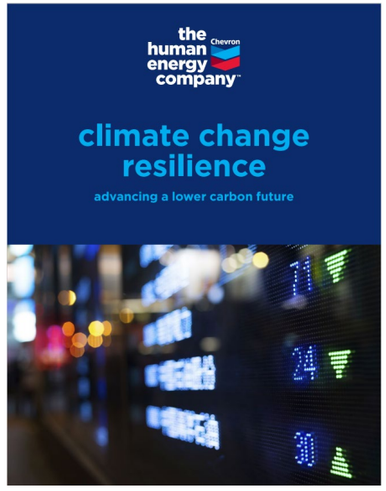


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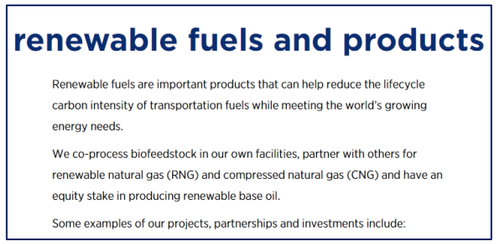


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