Oregon Low Carbon Fuel Standards

Oregon Carbon Intensities

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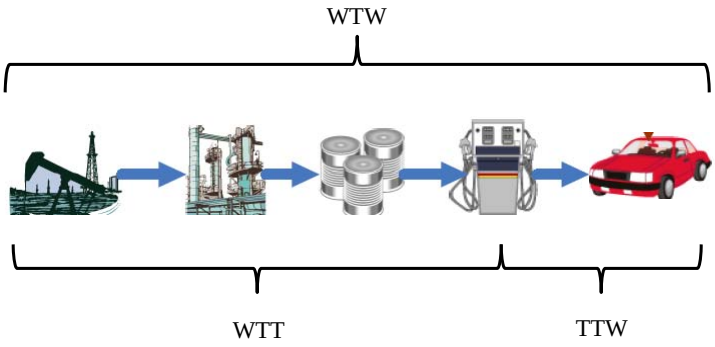
Slide 1

Life Cycle Analysis

- Why is life cycle analysis used in setting a low carbon fuel standard?
  - Tailpipe emissions are only a portion of the total emissions related to fuel use by vehicles



Slide 2

GREET (Greenhouse gases, Regulated Emissions, and Energy use in Transportation)

- GREET is a life-cycle model sponsored by the Argonne National Laboratory
- GREET is designed to calculate the energy use and greenhouse gas (GHG) emissions associated with production and use of fuels
- The most recent version is GREET 1.8c, available at http://www.transportation.anl.gov/software/GREET

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Carbon Intensity Values

- Expressed in emissions per unit of fuel energy (g/MJ)
- Components:
  - Fuel Life Cycle
    - Production/Storage/Transportation/Use
  - Adjustments
    - Co-products
    - Indirect effects, including land use change
    - Energy Economy Ratios or EERs (e.g., drive train efficiencies)

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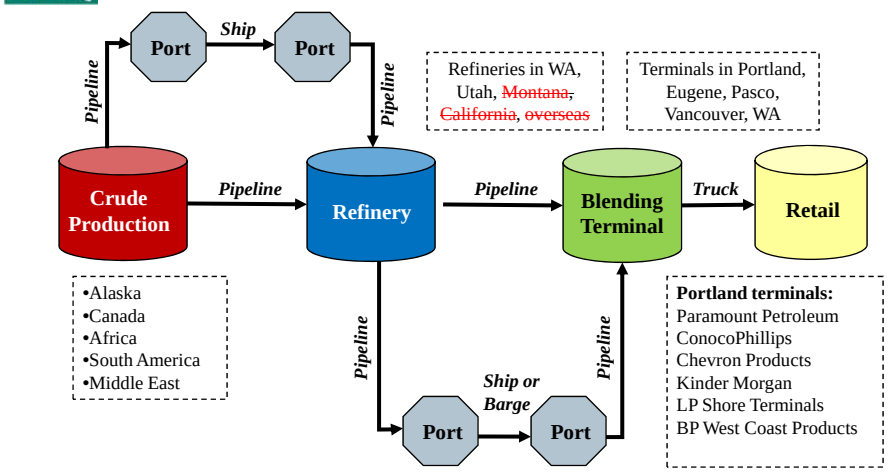
Oregon Petroleum Pathways



Source: TIAX LLC, modified for Oregon

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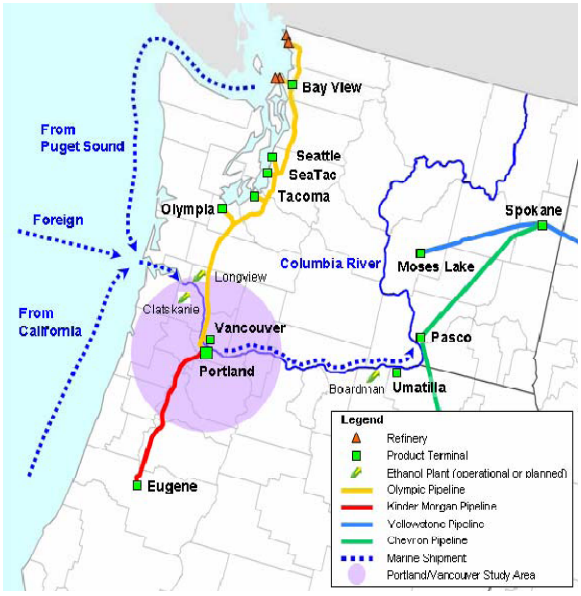
Where do Oregon's refined fuels come from?

About 90% of Oregon's Petroleum is Processed at Washington Refineries

- Transported along Olympic Pipeline (~65%, 217 miles)
- Ocean tanker (~35%, 329 miles)
- Barged to Pasco from Portland (~25% of the fuel transported to OR by pipeline and ocean tanker, 179 miles)
- Distributed by truck

10% Processed at Chevron Refinery (SL City, UT)

- Transported along Chevron Pipeline (~100%, 520 miles)
- Distributed by truck



Source: ICF International

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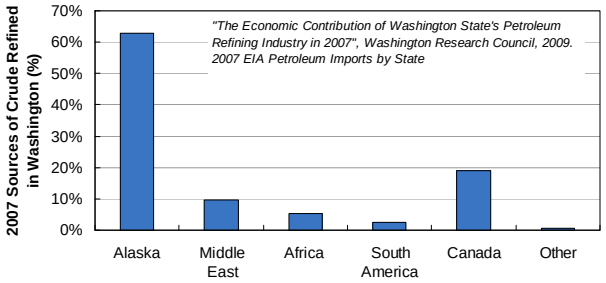
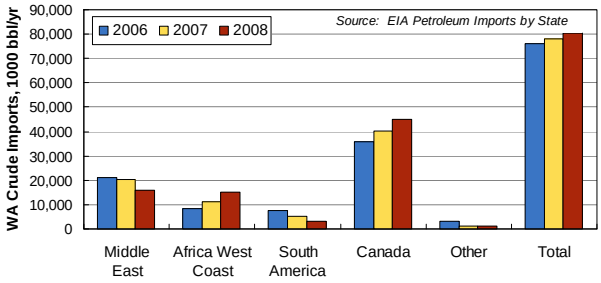
Sources of Crude Oil Used in Washington Refineries





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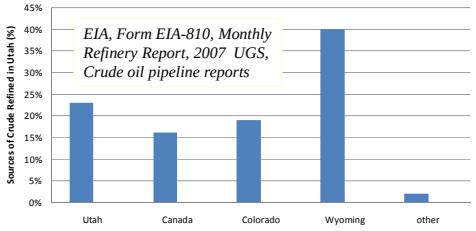
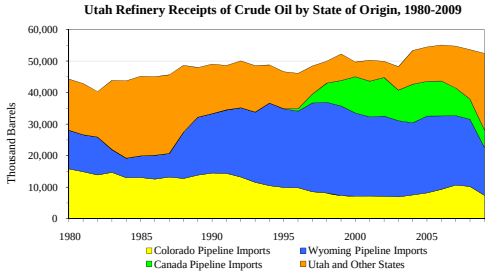
Sources of Crude Oil Used in Utah Refineries





Source: http://geology.utah.gov/emp/energydata/statistics/petroleum3.0/pdf/T3.15a%20&%20F3.8.pdf
http://geology.utah.gov/emp/energydata/oildata.htm

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Crude Oils from Canada: Conventional vs. Oil Sands

WA: 17% of crude refined is from Canada
Canada National Energy Board Report

http://www.neb.gc.ca/clf-nsi/rnrgynfmtn/sttstc/crdlndptrlmprdct/stmtdcndncrdlxprttpdstn-eng.html

2009 Exports to PADD V: 51% conventional; 49% oil sands

Utah: 16 % of crude refined is from Canada

http://www.neb.gc.ca/clf-nsi/rnrgynfmtn/sttstc/crdlndptrlmprdct/dspstnfdmstccrdlndmprts-eng.html

2009 Exports to Southern PADD IV: 25% conventional; 75% oil sands

Overall split:
WA: **~92% conventional ~8% oil sands**
UT: **~88% conventional ~12% oil sands**

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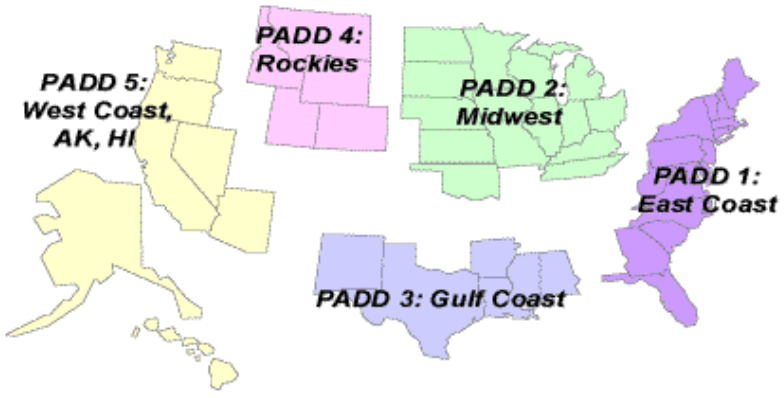
Petroleum Administration for Defense Districts



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OR-GREET Inputs for the Petroleum Pathways

- **Use GREET default values for conventional and oil sands energy consumption**
  - Process Efficiency – determines the amount of energy consumed in the process (processes are recovery and refining)
  - Process Fuel Shares – distributes the total energy consumed in the process among a variety of fuel types
  - Flaring and venting volumes
- **Use WA GREET Values for**
  - Crude transport distances and modes
  - Crude recovery electricity grid mixes
    - Oil Sands: Alberta
    - Conventional Crudes: Weighted average of Alberta, Alaska, Saudi Arabia, Angola, Argentina
  - Cargo ship crude oil payload values
    - 125,000 deadweight ton limit entering port of Seattle
    - 80,000 deadweight ton limit for Panama Canal
- **ADJUST**
  - Refined fuel transport distances
  - Refining electricity grid mixes (Washington and Utah)
  - WA and UT 2009 imports of Canadian conventional and oil sands crude
  - Use EPA RFS2 RIA numbers for vehicle CH4 and N2O emissions

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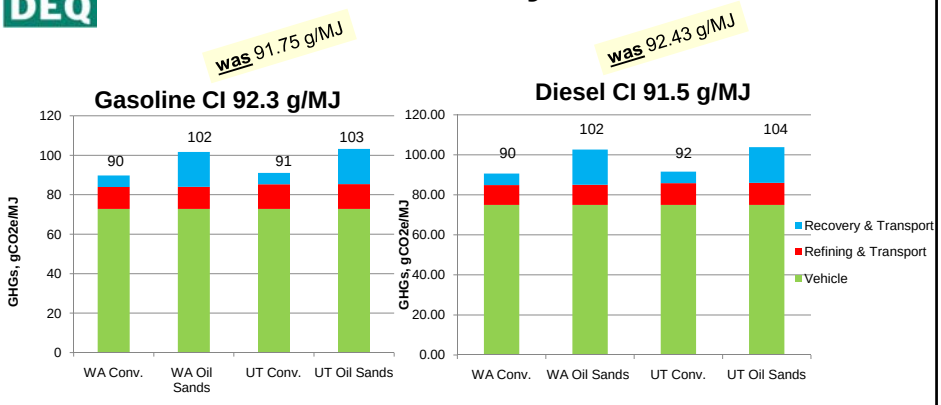
Draft Oregon Carbon Intensity Values



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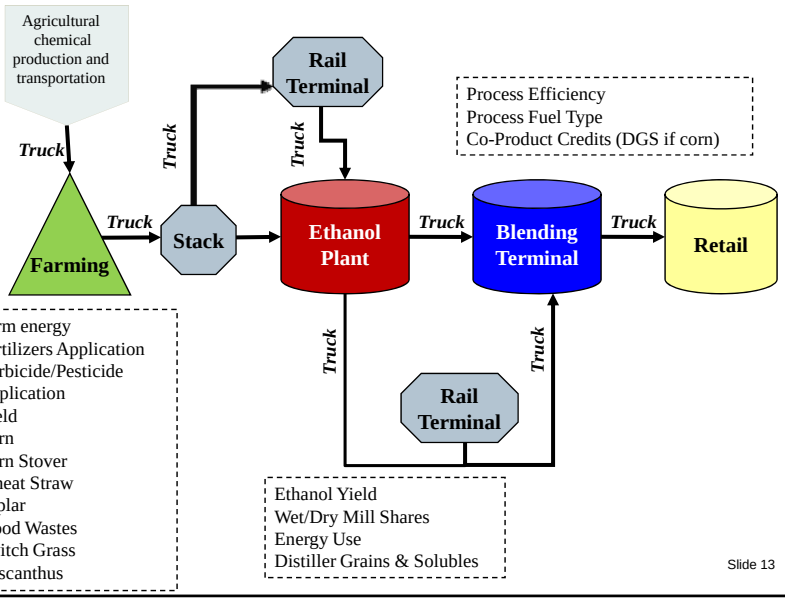
Oregon Ethanol Pathways



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Oregon Ethanol Considered Pathways

1. MW Corn Ethanol
2. MW Corn, NW Ethanol
3. NW Farmed Trees Ethanol
4. Wheat Straw
5. Forest Residue
6. Mill Waste
7. Sugarcane

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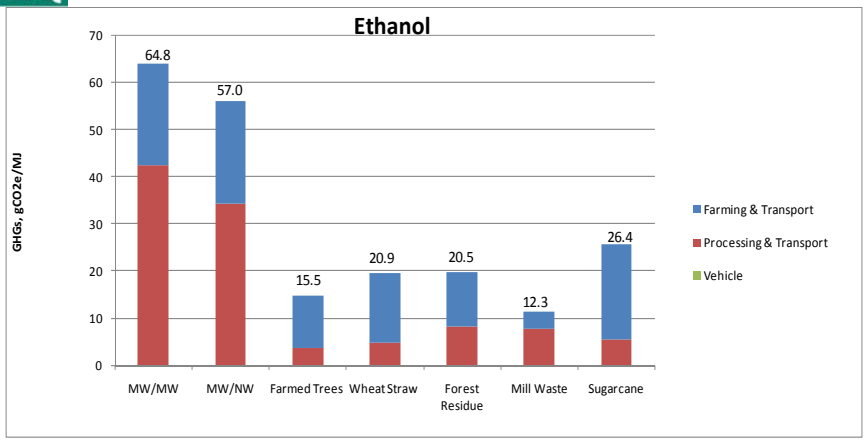
Draft Oregon Carbon Intensity Values



ILUC emissions are not accounted for

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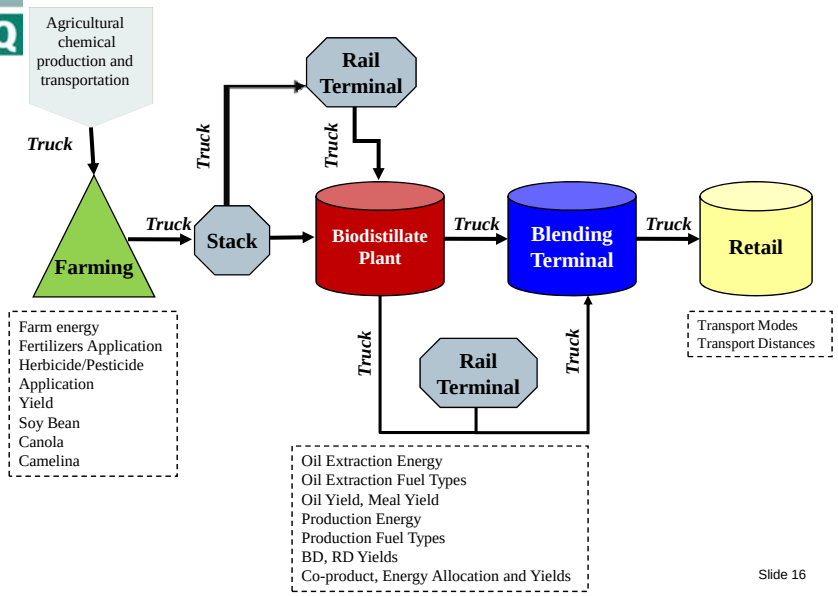
Oregon Biodiesel Pathways



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OR Biodistillate Considered Pathways

1. MW Soybean Biodiesel
2. NW Canola
3. Yellow Grease
4. Tallow
5. NW Renewable Diesel from MW Soybeans

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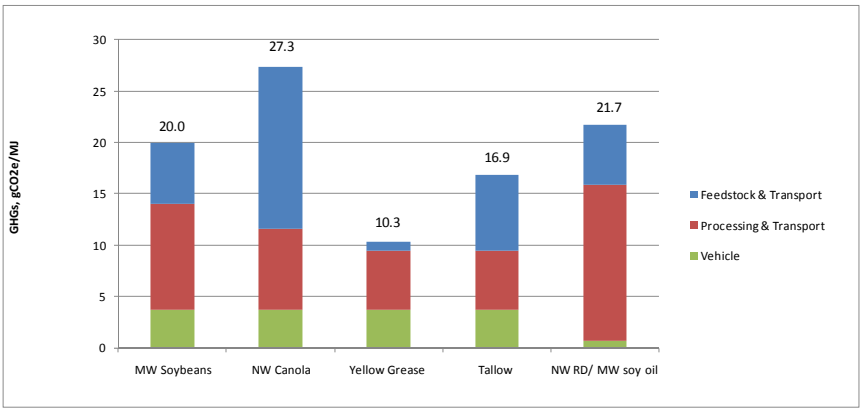
Draft Oregon Carbon Intensity Values

Biodistillate



ILUC emissions are not accounted for

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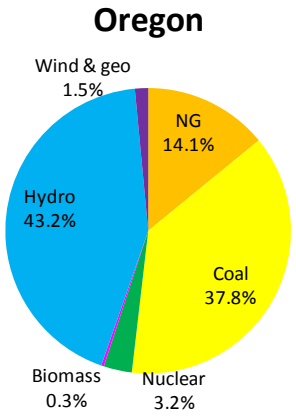
Oregon Electricity Pathway

Use Oregon 2007 Statewide Weighted Average provided by the ODOE



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Draft Electricity Pathway Results

- **Feedstock recovery and transport to the power plant:** 9 g/MJ
- **Electricity Production at the power plant:** 146 g/MJ
- **Vehicle Emissions:** 0 g/MJ
- **Total WTW:** 155 g/MJ

EER = Energy Economy Ratio

EER = Conventional Vehicle Energy Use per mile/EV Energy Use per mile
CARB EER for Light Duty Vehicles = 3
CARB EER for Heavy Duty Vehicles = 2.7

Electricity pathway Light Duty Vehicles **WTW CI = 51.7 g/MJ**

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Compressed Natural Gas (CNG) Pathway

Pipeline NG compressed to CNG at the refueling stations

GREET Defaults

- Recovery and Processing
  - Process fuel use ~ 53,000 Btu/MMBTU
  - NG recovery loss rate 0.35%
  - NG processing loss rate 0.14%
- NG Pipeline Transmission
  - 1200 miles from BC or Utah
  - Energy use 253 Btu/ton-mile
  - 94% NG compressors,
  - 6% electric compressors
- NG Properties
  - LHV = 983 BTU/lb
  - Density 22 g/cubic foot

WA/OR Adjustments

- Transmission Leakage
  - 0.08% leak rate independent of distance = 18 g/MMBtu NG transmitted (CARB)
- NG Compression (CARB)
- All station compressors are electric drive, OR mix
- Compressor efficiency 98%
- ***Draft*** CNG Carbon Intensity, g/MJ
  - recovery, processing, transport **8.2**
  - Compression **4.4**
  - Vehicle **58.8 + 0.2(CH4) +2.3(N2O)**
  - **WTW CI = 71.4 g/MJ**

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Summary of *DRAFT* Oregon Carbon Intensity Values

	WTT, g CO2e/MJ			TTW, g CO2e/MJ				WTW, g CO2e/MJ
Pathway	Feedstock & Transport	Production T&D	WTT Total	Vehicle CO2	Vehicle CH4	Vehicle N2O	Indirect Land Use Change	TTW Total w EPA equivalents
Gasoline Blendstock	6.80	11.23	18.03	72.83	0.07	1.41	0.00	92.34
ULSD	6.79	9.71	16.51	74.95	0.02	0.05	0.00	91.53
Ethanol, MW Corn Average	21.45	42.54	63.99	0.00	0.26	0.58	?	64.82
Ethanol NW production, MW Corn	21.77	34.39	56.16	0.00	0.26	0.58	?	56.99
Ethanol, Farmed Trees	11.03	3.68	14.71	0.00	0.26	0.58	?	15.54
Ethanol, Wheat Straw	15.29	4.78	20.07	0.00	0.26	0.58	0.00	20.90
Ethanol, Forest Residue	11.38	8.28	19.66	0.00	0.26	0.58	0.00	20.49
Ethanol, Mill Waste	3.68	7.80	11.48	0.00	0.26	0.58	0.00	12.31
Ethanol, Brazil Sugarcane	20.00	5.61	25.61	0.00	0.26	0.58	?	26.44
Biodiesel, MW Soybeans	6.00	10.29	16.29	3.04	0.01	0.65	?	19.99
Biodiesel, NW Canola	15.74	7.87	23.61	3.04	0.01	0.65	0.00	27.31
Biodiesel, Yellow Grease Average	0.83	5.75	6.58	3.04	0.01	0.65	0.00	10.28
Biodiesel, Tallow Average	7.40	5.75	13.15	3.04	0.01	0.65	0.00	16.85
RD, NW Production, MW soy oil	5.80	15.20	21.00	0.00	0.01	0.65	?	21.66
Electricity, 2007 OR avg. mix	2.96	48.70	51.66	0.00	0.00	0.00	0.00	51.66*
CNG, pipeline NG	8.24	4.35	12.59	56.32	0.20	2.30	0.00	71.41

* EER of 3 has been applied to Electricity pathway CI value.
- ILUC emissions are not included.

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