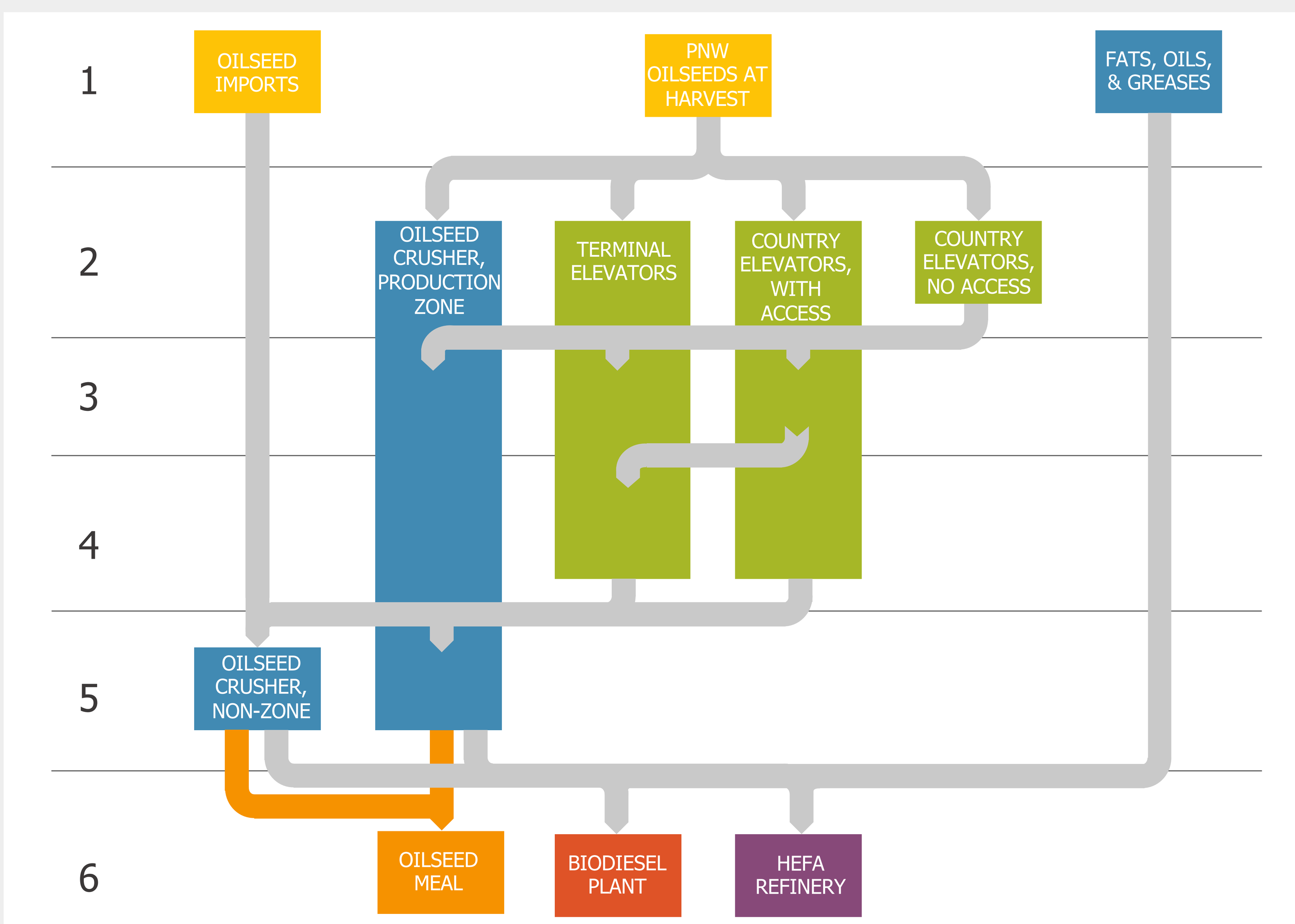
ASCENT 1: Alternative Jet Fuel Supply Chain Analysis

# SUPPLY CHAIN ANALYSIS FOR SUSTAINABLE ALTERNATIVE JET FUEL PRODUCTION FROM LIPID FEEDSTOCKS IN THE U.S. PACIFIC NORTHWEST

## Objectives

The objective of this work is to compare and optimize supply chain scenarios for sustainable alternative jet fuel (SAJF) produced from feedstocks sourced from the Pacific Northwest and converted to fuel using the HEFA (hydroprocessed esters and fatty acids) process. The supply chain model, shown below in Figure 1, describes interactions between entities across levels. Material sequentially flows down each level of the supply chain. Each entity adds, removes, modifies, or stores material. Entities are connected by links that represent truck, rail, or barge transportation.

### Figure 1: Supply Chain Model




**1) Inputs**

Any lipid feedstock can be used to produce SAJF. This study considers oilseeds produced within the PNW, oilseeds imported from other parts of North America, and FOGs (fats, oils, and greases).

**2) Short-Term Storage**

At harvest, oilseeds are delivered to storage. This may include storage at a grain elevator or an oilseed crusher. Short-term storage is subject to instantaneous storage capacity constraints.

**3,4) Long-Term Storage**

Long-term storage considers the same facilities, but does not consider instantaneous capacity.

**5) Oil Extraction**

Oil extraction occurs at an oilseed crusher. Crushers located near production have short-term storage capacity while non-production zone crushers do not. Vegetable oil and oilseed meal are produced during this step.

**6) Outputs**

Vegetable oil is delivered to biofuels production facilities. Oilseed meal is delivered to dairy production hubs for use in animal feed.

## Methods

### Model Solver

An optimized modeling approach is used to simultaneously balance costs between facility operations costs, facility installation costs, and transportation costs generated across the entire supply chain. The model is constructed using MASTRS (many-step transshipment solver), a Python-based tool that imports ArcGIS point and network dataset inputs and then builds and solves a mixed-integer linear program (MILP). MASTRS uses PuLP, a Python-based open-source general MILP solver.

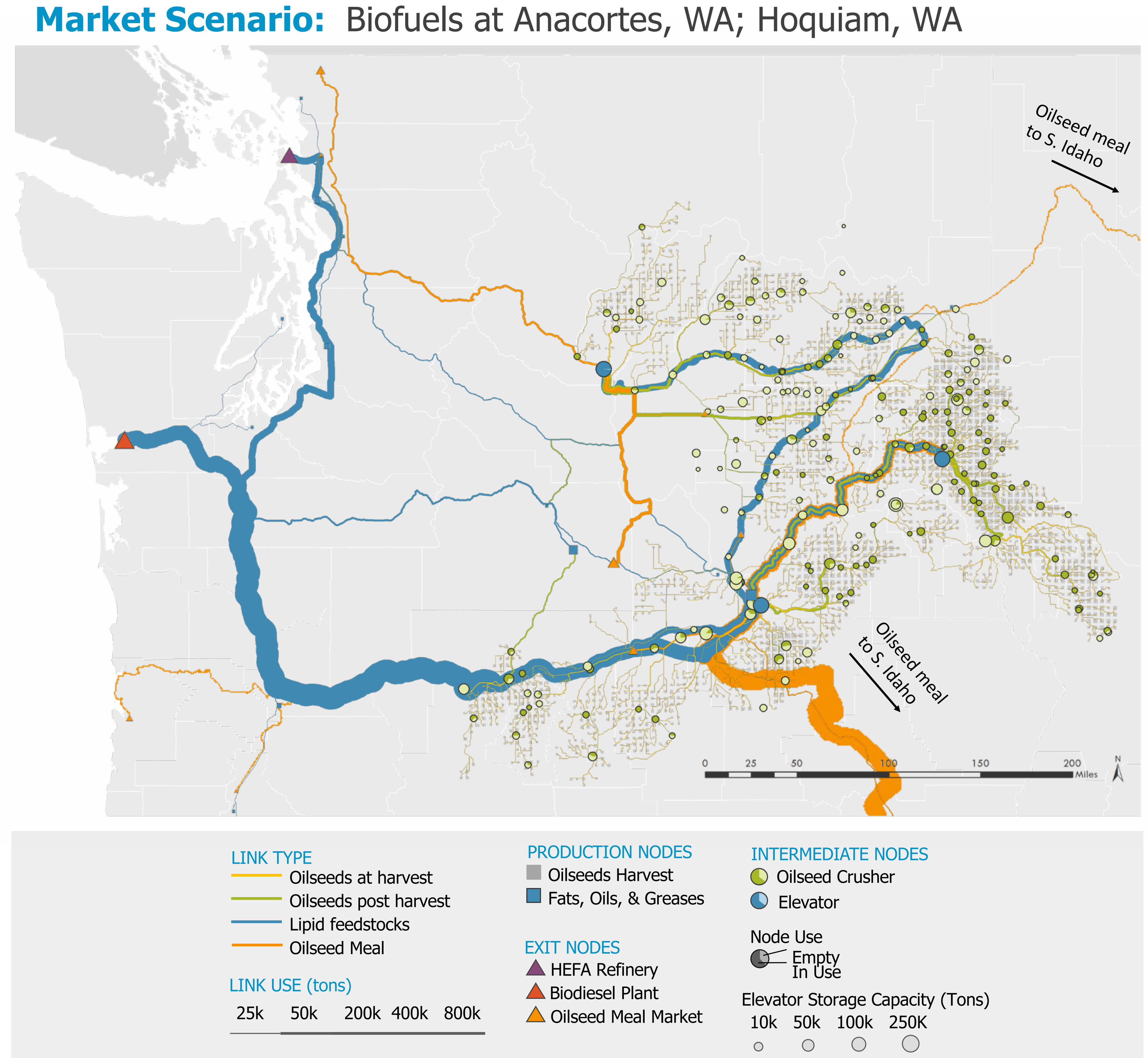
### Scenarios

Two feedstock (input) scenarios and three market (output) scenarios are used to produce six total supply-chain model runs. The 100% oilseed scenario represents a production scenario in which the maximum amount of oilseeds that could be produced within the PNW based on yield models and feasible adaptations to existing crop rotations. The 50% scenario is a simple 50% reduction of the 100% scenario. FOG production remains constant for either scenario. Two of the market scenarios consider a new HEFA refinery at an existing petroleum refinery in Anacortes, WA, or Tacoma, WA, in addition to an existing biodiesel plant in Hoquiam, WA. The third scenario considers the conversion of the existing biodiesel plant at Hoquiam to a HEFA refinery.

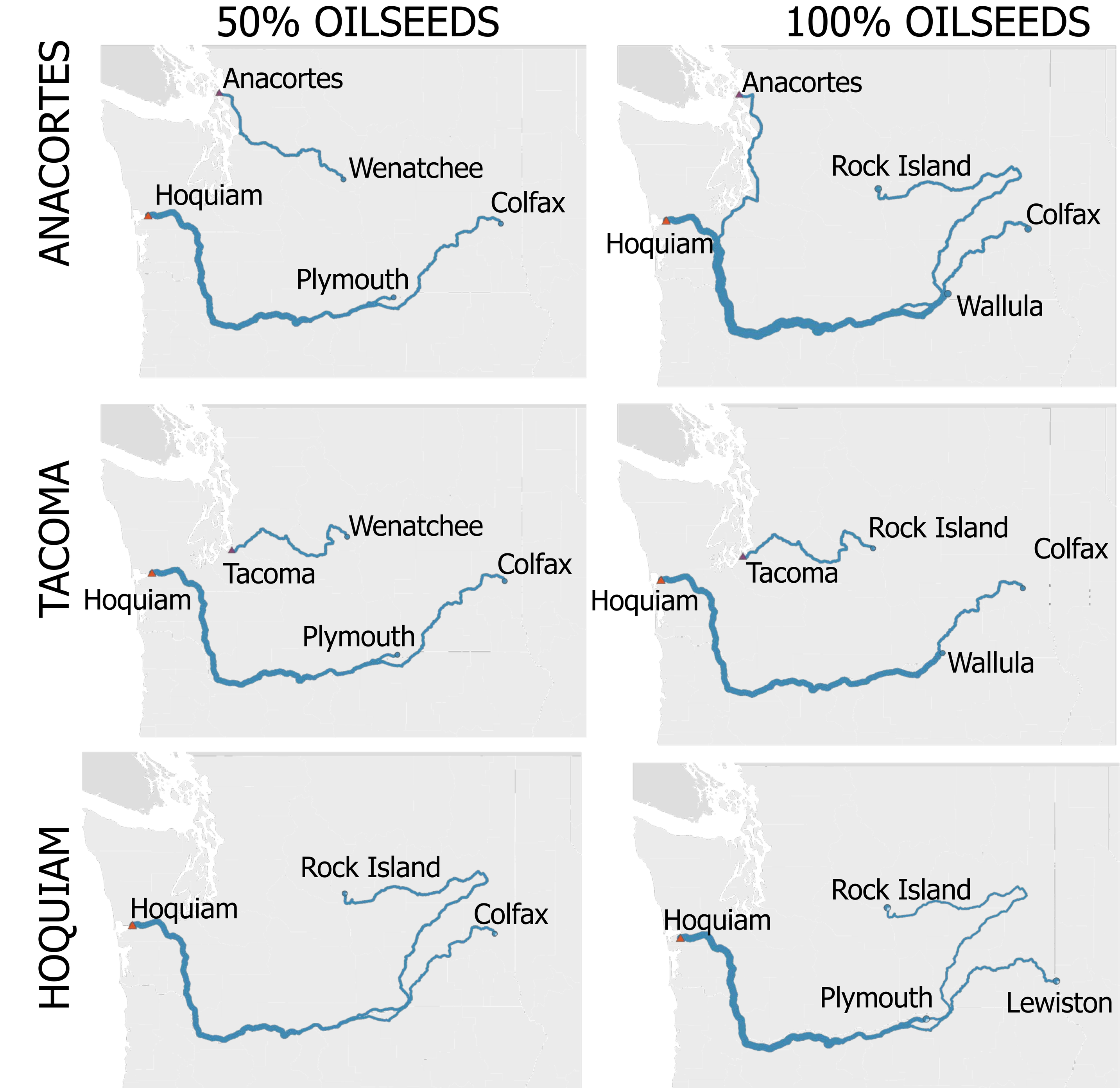
### Figure 2: Complete Model Run

**Feedstock Scenario:** 100% oilseeds, max FOGs

**Market Scenario:** Biofuels at Anacortes, WA; Hoquiam, WA




### Figure 3: Simplified Model Run Diagrams




## Results

A complete model run diagram is shown in Figure 2; it is more practical to demonstrate results of multiple runs using the simplified diagrams shown in Figure 3. Similar crusher locations were selected for each scenario. Of the 41 possible locations provided in the model, just 6 were used by at least one scenario. Rock Island and Wenatchee, Plymouth and Wallula, and Colfax and Lewiston are pairs with similar siting considerations and feedstock suppliers. Transportation of oilseeds to crushers was typically by truck, although short-line railways are used to deliver oilseeds to Wallula. Transportation from crushers was a mixture of truck and unit-rail transportation, depending on the distance to markets. Crusher selections were always near the oilseed production zone. This reduced total transportation costs; the two products from a crusher have markets that spread in opposite directions. In addition, the processing costs were reduced from the low electricity costs found in the Columbia River Basin. Because FOGs are disaggregated across the region, and make up just 16% of total feedstock use, they are typically sent to the nearest lipid feedstock market.

## Conclusions

A market for SAJF will develop from Seattle-Tacoma International Airport soon [1], and HEFA jet fuel offers one of the best opportunities to meet that demand in the near and distant future. Additional work should focus on the expansion of oilseed production, as FOG volumes are limited because they are food wastes and minor byproducts of other industries.


[1] Port of Seattle, "Port of Seattle Announces Partnership for Sustainable Aviation Fuels at Sea-Tac Airport," 2018.



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