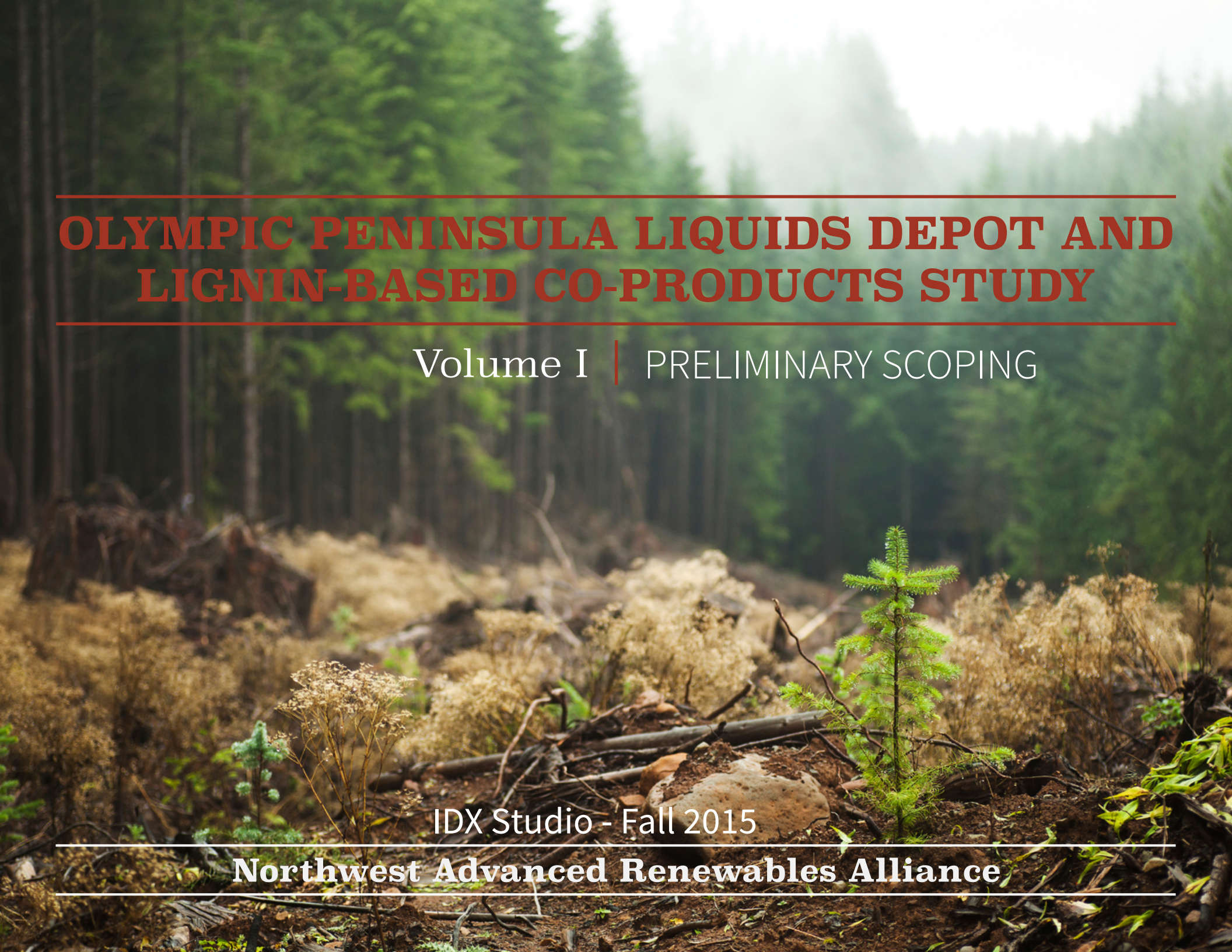

OLYMPIC PENINSULA LIQUIDS DEPOT AND LIGNIN-BASED CO-PRODUCTS STUDY

Volume I | PRELIMINARY SCOPING

IDX Studio - Fall 2015

Northwest Advanced Renewables Alliance

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This project is part of the Northwest Advanced Renewables Alliance (NARA), supported by the Agriculture and Food Research Initiative Competitive Grant no. 2011-68005-304 from the USDA National Institute of Food and Agriculture.

Thank you to our project partners throughout the Olympic Peninsula and the entire NARA Study Region. We look forward to working with you this coming year!

NARA is led by Washington State University and supported by the Agriculture and Food Research Initiative Competitive Grant no. 2011-68005-30416 from the USDA National Institute of Food and Agriculture.

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ABBREVIATIONS

BDT	Bone Dry Tons
Brownfield	Abandoned or underutilized site with real or perceived contamination
C&D	Construction and Demolition Debris
CIA	Community Impact Analysis
Greyfield	Vacant or underutilized industrial site with no known contamination
IBR	Integrated Biorefinery
LCA	Life Cycle Analysis
MC2P	Mid Cascades to Pacific Supply Chain Region
MRF	Material Recycling Facility
NARA	Northwest Advanced Renewables Alliance
PNW	Pacific Northwest
PTPC	Port Townsend Paper Corporation
RWW	Recycled Wood Waste
UI	University of Idaho
USFS	United States Forest Service
WMC	Western Montana Corridor
WSU	Washington State University

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Northwest Advanced Renewables Alliance

Olympic Peninsula Case Study

1.0.0 EXECUTIVE SUMMARY

The Northwest Advanced Renewables Alliance (NARA)—a collaboration among universities, government, and industry and supported by a $40 million US Department of Agriculture grant awarded to Washington State University in 2011—is examining the feasibility of producing liquid biofuels for use in the aviation sector (i.e., biojet fuel) and bio-based co-products from post-harvest forest residuals and construction and demolition (C&D) waste in Oregon, Washington, Idaho, and Montana. Each year, the Integrated Design Experience (IDX) course, part of the Washington State University's Institute for Sustainable Design, addresses projects that require an integration of disciplines to develop inspired design solutions. As part of NARA, IDX conducts supply chain analysis and facility site selection in the four state NARA region.

During 2015/2016, building on previous supply chain studies, IDX is examining the biofuels supply chain in the Olympic Peninsula (OP). The overall goal of the Olympic Peninsula Study is to provide a framework that can bring better understanding of links among material handlers, processors, producers, and markets for wood-based biofuels and co-products. Analysis will focus on constraints to material gathering, transport, production, and markets, clarify the relationship among the participants in the supply chain, and determine the benefits for different players. The IDX process is unique in that the OP supply chain study involves the collaboration of existing pulp and paper facilities determined to be among the top sites for locating a forest residuals conversion facility.

Specifically, IDX will examine the potential for co-locating a biofuels facility at the Port Townsend Paper Corporation (PTPC) in Port Townsend, WA and the Nippon Paper Industries in Port Angeles, WA. The analysis will consider co-locating liquids depots and lignin recovery facilities at these sites, assess potential markets for liquid sugars and lignin, and examine community perceptions.

A successful biofuels and co-products supply chain study requires participation by relevant regional collaborators. The OP has been selected, in part, because of the stakeholders willing to work with IDX. Furthermore, the region has been exploring green electricity and green fuels produced from wind, solar and woody biomass (CountyEnergy.US/JeffWA 2015). Hermann Brothers Logging and Construction, Inc. in Port Angeles, WA is providing information related to feedstock collection, handling, processing and transporting. Key personnel from PTPC and Nippon are providing site access and data, and feedback on student research and design concepts. IDX is working closely with WSU Extension Directors in Clallam, Jefferson and Mason counties to engage with regional stakeholders and understand community perceptions.

1.1.0 INTRODUCTION

1.1.1 NARA PROJECT INTRODUCTION

The Northwest Advanced Renewables Alliance (NARA) is a Coordinated Agricultural Project (CAP) funded under the U.S. Department of Agriculture's National Institute of Food and Agriculture (NIFA) Sustainable Bioenergy Program (Award 2011-68005-30416). NARA is examining the environmental, economic and social feasibility of a regional system for sustainable production of biofuels and biobased co-products from woody biomass, specifically softwood forest residuals, in Washington, Oregon, Idaho and Montana. The USDA defines woody biomass as the trees and woody plants, including limbs, tops, needles, leaves, and other woody parts, grown in a forest, woodland, or rangeland environment, that are the by-products of forest management (USDA 2008). In addition to focusing on post-harvest forest residuals, NARA is also examining construction and demolition (C&D) wood waste (indifferent to species) as a potential feedstock. In this document the term woody biomass refers to softwood forest residuals.

NARA's goals are to develop:

1) SUSTAINABLE BIOJET: Develop a framework for a sustainable biojet fuel industry in the Pacific Northwest that uses residual woody biomass as feedstock
2) VALUE-ADDED CO-PRODUCTS FROM LIGNIN: Create valuable co-products made from lignin, an industrial byproduct of the woody biomass-to-biojet process
3) RURAL ECONOMIC DEVELOPMENT: Sustain and enhance rural economic development
4) REGIONAL SUPPLY CHAIN COALITIONS: Facilitate and promote supply chain coalitions within the NARA region for wood-to-biofuel supply chain analysis
5) BIOENERGY LITERACY: Improve bioenergy literacy to develop a future workforce and enhance stakeholder understanding

NARA is organized into five teams (see Figure 1.1.1):

1) THE FEEDSTOCK TEAM takes a multi-pronged approach to the development and sustainable production, efficient accumulation and transportation of feedstocks from wood materials, including forest residuals and wood debris from construction and demolition.
2) THE CONVERSION TEAM works to provide a wood-derived replacement for aviation biofuel and other petroleum-derived chemicals that is economically and technologically feasible. The goal is to collect low-market-value materials and convert them to high-value products in order to overcome the relatively high cost of densifying and transporting biomass.
3) THE SUSTAINABILITY MEASUREMENTS TEAM evaluates and assesses environmental, social, and economic viability of the wood-to-biofuels supply chain. The life cycle assessment (LCA), community impact analysis (CIA), and techno-economic analysis (TEA) groups are conducting much of these analyses.
4) THE OUTREACH TEAM transfers research-based science and the technology of converting woody biomass into biofuels and co-products to stakeholders and works to facilitate regional coalitions to foster the emerging wood-based biofuels industry in the Pacific Northwest.
5) THE EDUCATION TEAM engages citizens, meets future workforce needs, enhances science literacy in biofuels, and helps people envision their role in the new energy economy.

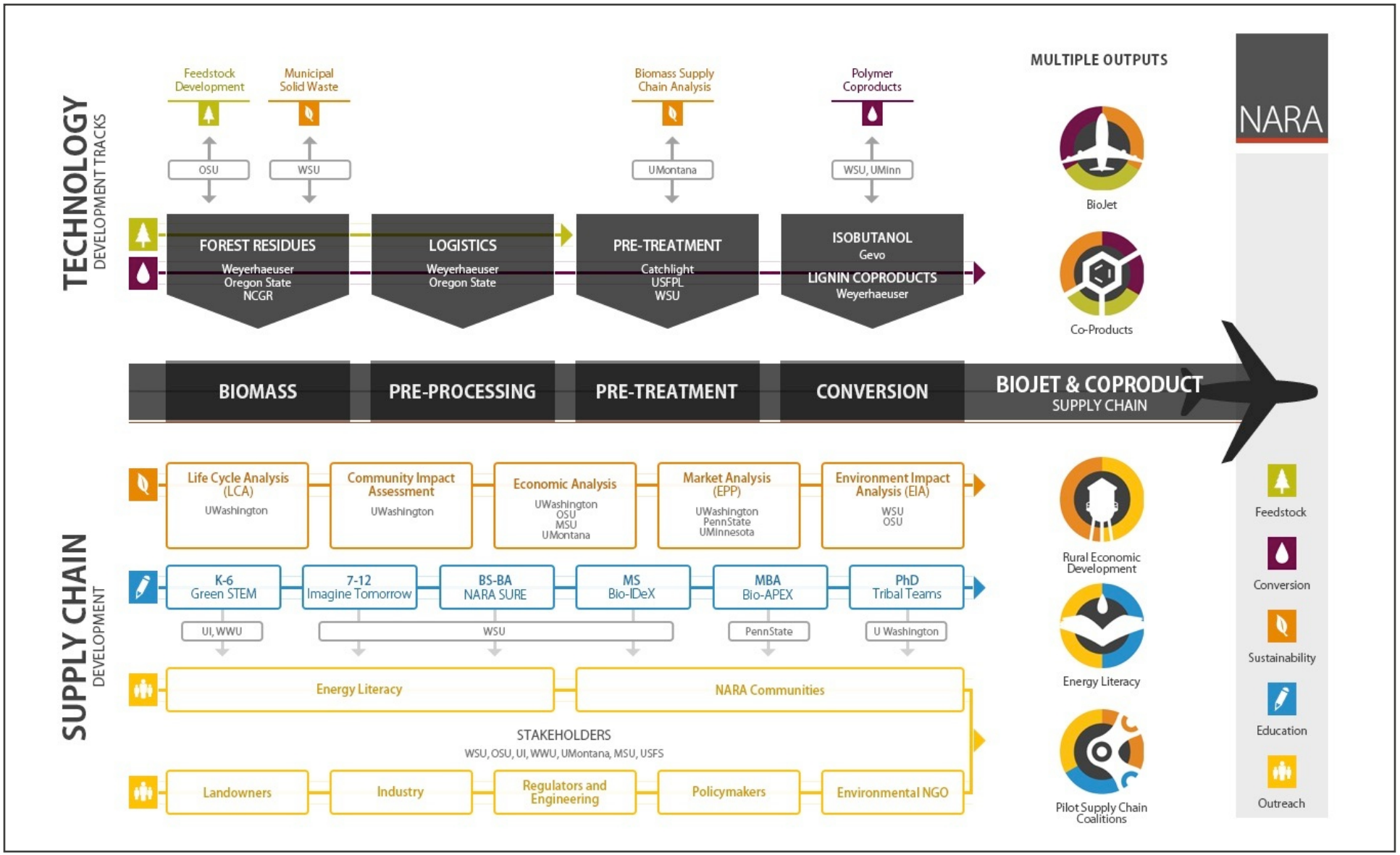

Figure 1.1.1. NARA Team Structure and Goals

1.1.2 NARA SUPPLY CHAIN OVERVIEW

A supply chain is a system developed to move products or services from supplier to consumer; it is composed of organizations, people, technology, activities, information, and resources. Activities along the supply chain transform natural resources, raw materials and components into finished products delivered to the end consumers. Supply chain management for woody biomass to biofuels conversion involves activities from harvesting of the feedstock to transportation by one or several modes (e.g., road, rail, barge), pre-conversion (mechanical size reduction and densification), pretreatment, conversion, refining, and final biofuels delivery to consumers (e.g., commercial and military airports). In this project, the woody biomass to biofuels and co-products supply chain is shown in Figure 1.1.2. A detailed explanation of supply chain steps is available in the Pacific Northwest Wood-Based Biofuels Preliminary Scoping document (https://www.nararenewables.org/pacific-northwest/docs/Vol1-Profile.pdf).

Co-products are outputs produced from waste material in the biofuels production process. For example, lignin, a non-carbohydrate constituent found in the cell walls of plants and trees, is often dried and burned in boilers. However, lignin can be used to produce a number of value-added products including 1) activated carbon products, 2) cement additives, 3) thermosetting resins, and 4) thermoplastic polymers. NARA's techno-economic analysis shows that producing co-products is critical to enhancing the profitability of producing biofuels (NARA 2015).

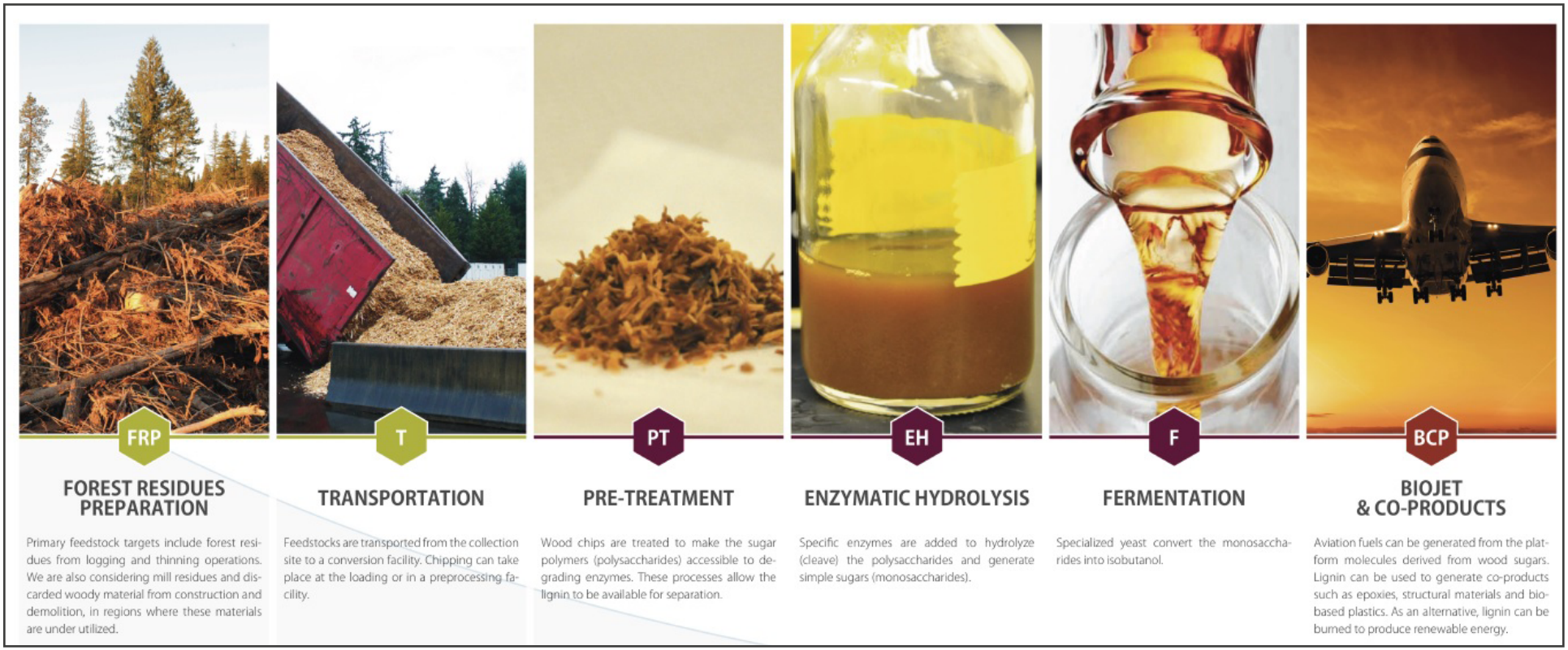

Figure 1.1.2. Overview of NARA Supply Chain

1.1.3 IDX OVERVIEW

The Integrated Design Experience (IDX), which engages with NARA teams, brings university students and faculty together with regional stakeholders to contribute to the NARA goal of developing supply chain coalitions throughout the Pacific Northwest. IDX explores and examines the activities and linkages that work together along the supply chain to provide assistance to communities in determining opportunities for investment along the supply chain and in examining their potential roles in the emerging wood-based biofuels economy.

IDX goals include:

1) Giving students skills in collaborative research, problem-solving, and design methods to utilize in their academic and professional work.
2) Training a workforce ready to participate in the renewable energy and biofuels industry.
3) Providing technical assistance to communities interested in participating in the emerging biofuels economy.

IDX draws on undergraduate and graduate students from Washington State University, the University of Idaho and Western Washington University who are interested in identifying innovative solutions to complex, contemporary, real-world challenges. Faculty with expertise in engineering, design, planning, and economics facilitate IDX, which attracts students seeking degrees in engineering (civil, mechanical, environmental), architecture, landscape architecture, bioregional planning and community design, law, business, environmental science, renewable materials and other disciplines.

IDX works with regional partners on identifying community assets, conducting site selection, and resource flow and supply chain economic analyses, as well as site specific designs for solids and liquids depots and integrated biorefineries. Every year, IDX produces a regional Analysis report that focuses on providing analyses of the supply chain and a Design portfolio that showcases innovative concepts and designs for selected production sites and linkages within the supply chain.

1.2.0 NARA MODELS AND METHODOLOGY

1.2.1 NARA SUPPLY CHAIN MODELS

NARA considers two models to facilitate a complete wood-based biojet fuel supply chain. One model is built around a large centralized integrated biorefinery (IBR), a high-capacity plant that takes biomass from post-harvest forest residuals or other wood-based residuals all the way to biojet fuel.[1] The second model is a distributed production approach, where depots could produce intermediate products (i.e. refined and sorted biomass, wood-based sugar-rich liquids, isobutanol). These distributed operations could help maintain economies of scale for other core processes, such as fermentation and conversion of alcohol to biojet fuel. Four facility types are being analyzed. They are described below and illustrated in Figure 1.2.1.

1) DEPOT FACILITY: a pretreatment facility that prepares the biomass for processing in a conversion plant. Two depot options are investigated and are detailed as follows:

   Solids Depot: a pre-conversion facility that receives post-harvest forest residuals, forest thinnings, and/or C&D waste biomass. Mechanically processed materials could be shipped by rail or highway truck to a receiving liquids depot, conversion plant, IBR or other potential end user (e.g., fuel pellet manufacturer).

   Liquids Depot: a pre-treatment facility that receives raw and mechanically processed woody residuals directly from nearby forests, or chips from a solids depot. A liquids depot produces a concentrated sugar-rich syrup that would be transported for conversion to isobutanol at a conversion plant for further refining into biojet fuel or other chemical conversion facilities.

2) CONVERSION PLANT: a high-capacity plant that takes in chips from a solids depot or liquid sugars from a liquids depot and produces isobutanol.

3) Integrated Biorefinery (IBR): a high-capacity plant that converts biomass from post-harvest forest residuals or other woody residuals all the way to biojet fuel.

The centralized and distributed production models each aim to produce biojet fuel as the final product. The NARA four state region has diversified supply chain assets across a vast geography. Since 2011, IDX has evaluated both supply chain models based on existing assets in the region, evaluating best sites for locating particular facilities. Previous regional studies conducted by IDX are listed below and can be found on the NARA website: https://www.nararenewables.org/features/supply-chain-analyses.

- Clearwater Basin Study, North Central Idaho, 2011/2012
- Western Montana Corridor (WMC) Study, 2012/2013
- Mid-Cascade to Pacific (MC2P) Study, 2013/2014
- NARA Pacific Northwest Region (WA, OR, ID, MT) Study, 2014/2015

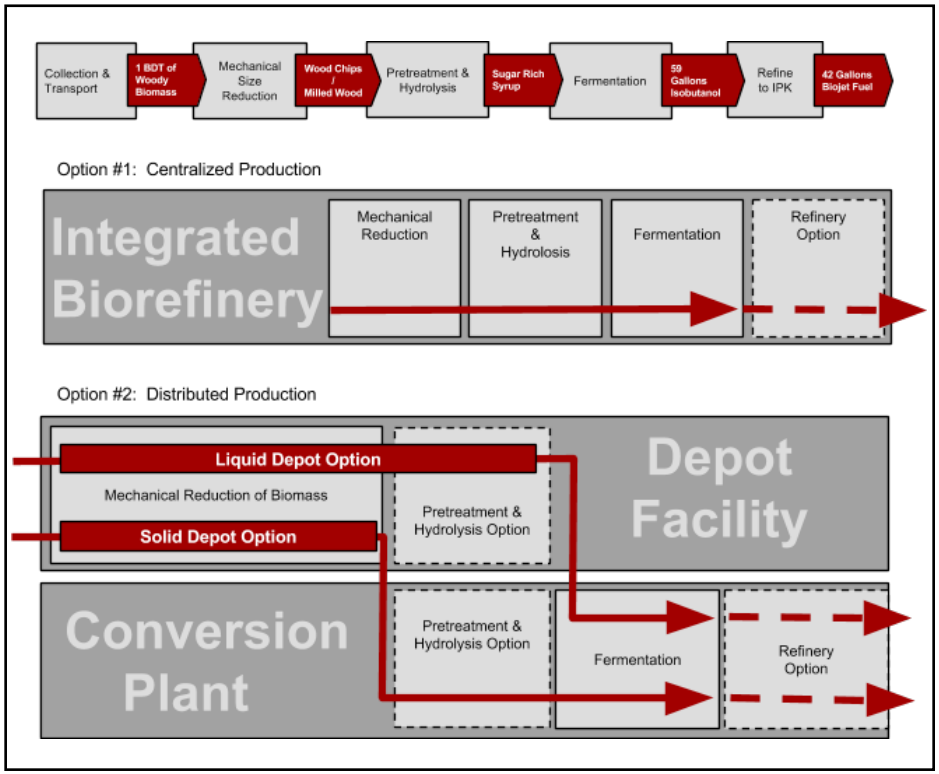

Figure 1.2.1. Wood to Biofuels Supply Chain Pathway Options

1 NARA techno-economic analysis estimates that a full-scale IBR would require 770,000 bone dry tons (BDT) of woody biomass annually and produce about 32 million gallons of biofuel.

1.2.2 IDX SITE SELECTION METHODOLOGY

IDX has developed a site selection methodology and biomass supply curves for the NARA four state region. The site selection methodology is a systematic process for identifying locations for solids and liquids depots, conversion plants and IBRs that could supply regional markets with biojet fuel. In this process existing sites (such as sawmills or pulp and paper mills) are identified as potential sites due to the reduced capital cost of using existing infrastructure, land, and permits. Using a site selection database and decision matrix, IDX is able to identify and rank viable processing sites in each potential market region for converting forest residuals to biojet fuel. Figure 1.2.2 shows the Pacific Northwest jet fuel demand centers. The site selection process is broken into two steps: site identification and site inventory.

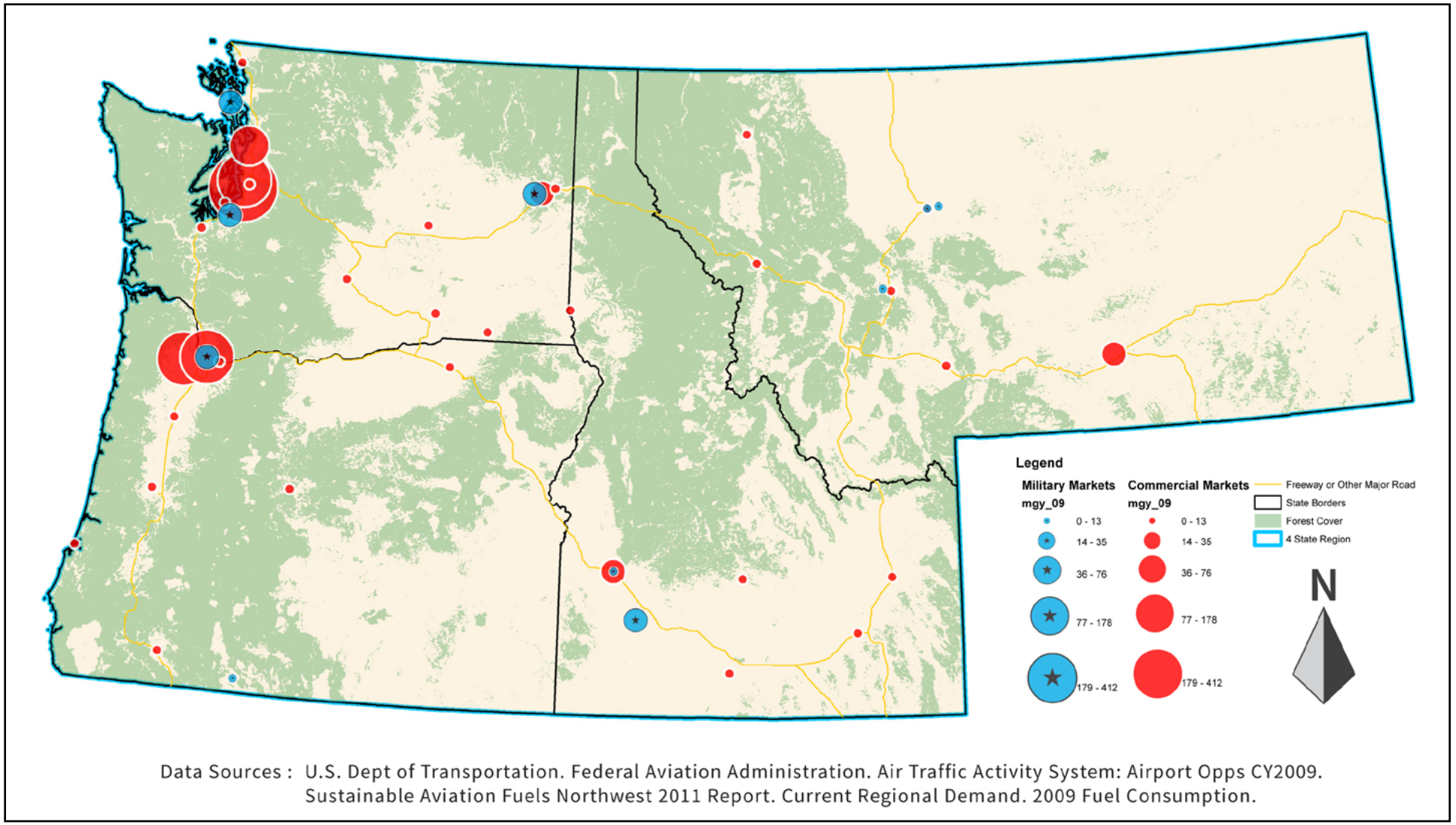

Figure 1.2.2. Pacific Northwest Aviation Markets and Demand Centers

Step 1: Site Identification

IDX identifies regional assets important for determining site selection for the four biofuels facility types. The assets IDX uses to identify preliminary sites are:

- Biomass availability
- Transportation assets: access to road, rail and port
- Facility type: saw/chip mill, pulp/paper (sulfite, kraft, thermo-chemical), ethanol plant, oil refinery, petroleum terminal
- Proximity to market
- Social Assets: social capital, creative vitality index, poverty rate
- Utility rates: natural gas, electrical
- Labor costs

Asset data is entered into the site selection database and decision matrix. Potential sites are given scores for each asset ranging on a scale of -5 to 5. Weights are also given to each asset depending on 1) the importance of the asset for the facility type (e.g., biomass availability is weighted more for a solids depot than an IBR, while proximity to markets is weighted more for an IBR than a solids depot), and 2) the cost/worth of particular assets based on the NARA techno-economic analysis estimates for capital and operational costs.

The assets are mapped using geographic information systems (GIS) and then layered to produce hotspots, indicating sites of significant interest. Figure 1.2.3 shows the hotspot layering technique used to identity preferred site locations.

The site selection analysis was completed for solids and liquids depots, conversion and IBR facilities in the NARA four state region. A total of 24 potential solids and liquids depots, and 18 potential conversion and IBR facilities were identified in the first round of site selection analysis.

Step 2: Site Inventory

After the initial identification of sites, IDX inventories sites based on specific assets: site size, business and operations taxes, permitting, wastewater facility, boiler, and other onsite infrastructure. This more detailed analysis reduces the number of potential sites by ensuring that the remaining sites meet the necessary requirements for hosting a biofuels production facility. A presentation for the PNW Site Selection Analysis, is available here: www.youtube.com/watch?v=bdhxKjv-qb0.

After completing the PNW Site Selection Analysis, IDX further refined facility programming (purpose and necessary activities) and volume calculations for various site operations and addressed the facility's proximity to the biojet market and demand centers. The original 770,000 BDT volume of biomass used for an IBR was "right-sized" for potential biojet fuel markets throughout the PNW region. This analysis worked backwards from the end of the supply chain, the customer, toward production and feedstock. Four sub-regional analyses were conducted: the Olympic Peninsula, Northern Oregon, Southern Oregon, and the Western Montana Corridor (Figure 1.2.4). Two sites on the Olympic Peninsula were identified as optimal locations for potential liquids depots and will be analyzed in further detail in the 2015/2016 time frame. Chapter 1.3 describes the Olympic Peninsula Study in greater detail.

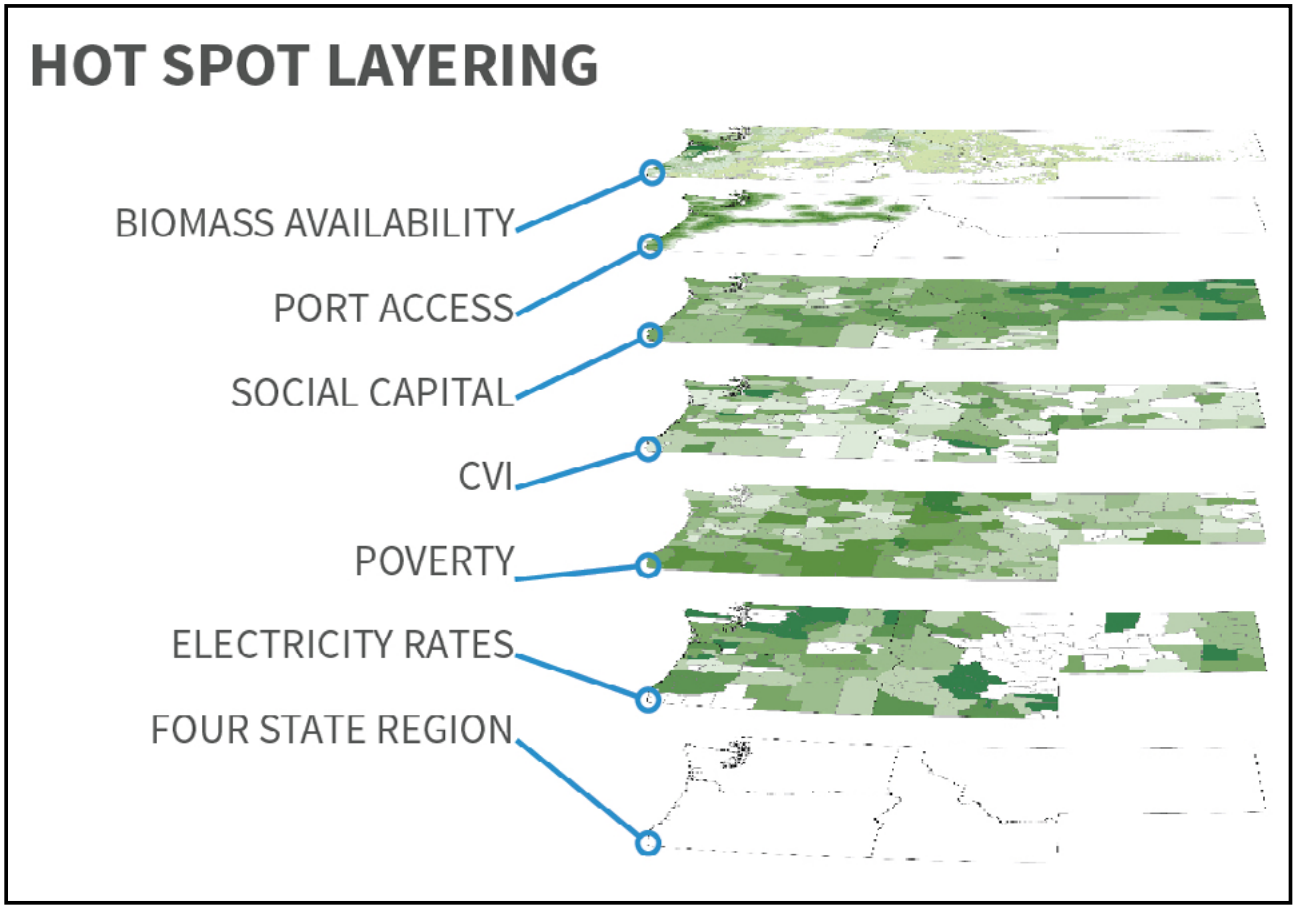

Figure 1.2.3. Hotspot Layering Technique to Identify Site Locations

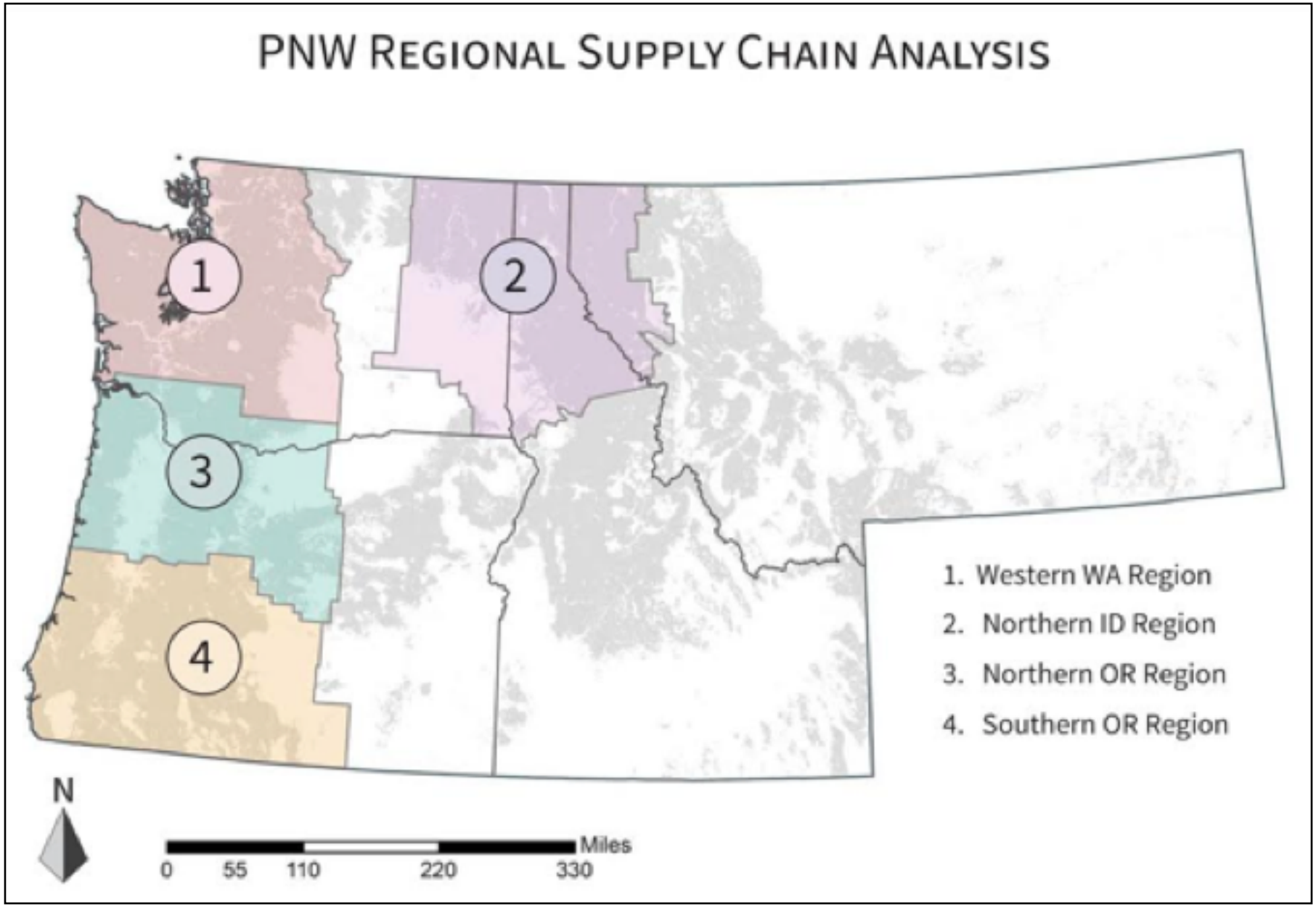

Figure 1.2.4. NARA Study Regions: the Olympic Peninsula, Northern Oregon, Southern Oregon, and the Western Montana Corridor

1.3.0 OLYMPIC PENINSULA LIQUIDS DEPOT AND LIGNIN-BASED CO-PRODUCTS STUDY

1.3.1 OLYMPIC PENINSULA STUDY GOALS AND OBJECTIVES

During 2015/2016, IDX is studying the biofuels supply chain on the Olympic Peninsula. Specifically, IDX will examine the potential for co-locating a biofuels facility, in this case a liquids depot and lignin recovery facility, at Port Townsend Paper Corporation (PTPC) in Port Townsend, WA and Nippon Paper Industries (Nippon) in Port Angeles, WA.

The overall goal of the Olympic Peninsula Study is to provide a framework to bring better understanding of the linkages between material handlers, processors, producers, and markets for wood-based biofuels and co-products. Analysis will focus on constraints to material gathering, transport, production and markets, and clarify the relationship among the players in the supply chain, and determine the benefits for different players.

The three study objectives are:

1) Analyze and design a co-located liquids depot at existing pulp and paper mills, with analysis of biomass requirements and potential markets
2) Analyze and design a lignin recovery facility at existing pulp and paper mills, with analysis of biomass requirements and potential markets
3) Assess community perceptions in Clallam and Jefferson counties related to wood-based biofuels and co-products production

The study will examine drivers of the supply chain on the Olympic Peninsula. Thematically, they fall under:

1) Inputs – forest residuals, land, workforce, capital
2) Technologies – across the supply chain (methods, processes, facilities, and equipment)
3) Product demand – liquid sugar and lignin co-products
4) Market Structure – distribution channels and existing competing markets
5) Political and social environment: policies, supporting institutions, community perceptions and long-term goals

A successful biofuels and co-products supply chain study requires participation by relevant regional collaborators. The OP has been selected, in part, because of the stakeholders willing to work with IDX. Furthermore, the region has been exploring green electricity and green fuels produced from wind, solar and woody biomass (CountyEnergy.US/JeffWA 2015). Hermann Brothers Logging and Construction, Inc in Port Angeles, WA is providing information related to feedstock collection, handling, processing and transporting. Key personnel from PTPC and Nippon are providing site access and data, and feedback on student research and design concepts. IDX is working closely with the WSU Extension Directors in Clallam, Jefferson and Mason counties to engage with regional stakeholders and understand community perceptions.

Figure 1.3.1 schematically shows current usage (in solid blue lines) of biomass by PTPC and Nippon for production of pulp and paper products as well as energy products (heat and power). Proposed feasibility analysis for added capacity by IDX in Year 5 is also shown in the figure with dashed blue lines. A detailed illustration of co-locating a liquids depot and lignin recovery facility and their role within existing pulp and paper facilities is shown in Figure 1.3.2. As these figures demonstrate, primary analysis during this year will focus on feasibility analysis of producing liquid sugars for downstream conversion into other products (bioplastics and biofuels) and installing a lignin recovery facility for generating lignin-based co-products.

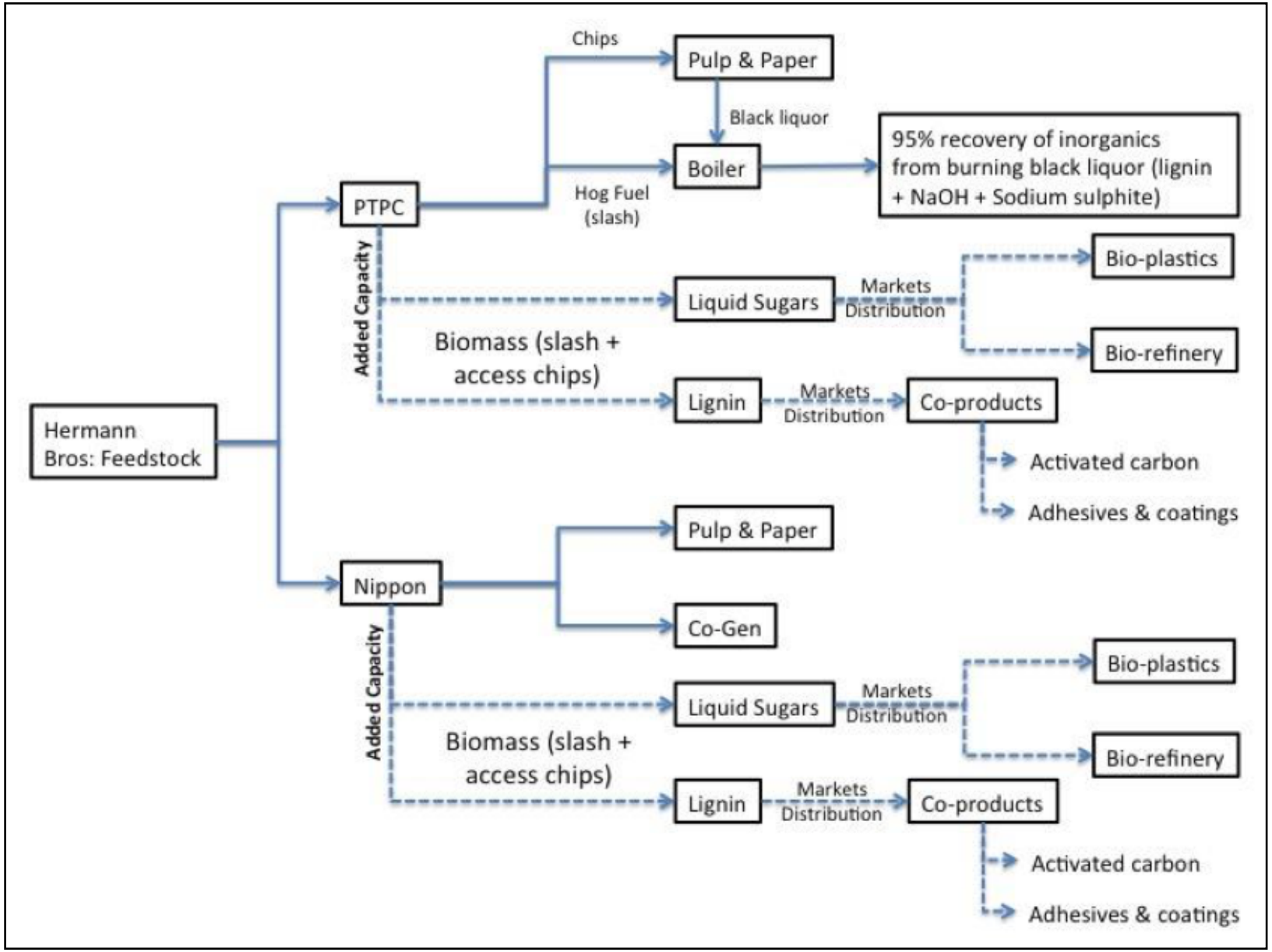

Figure 1.3.1. Current woody biomass use at PTPC and Nippon and proposed added capacities

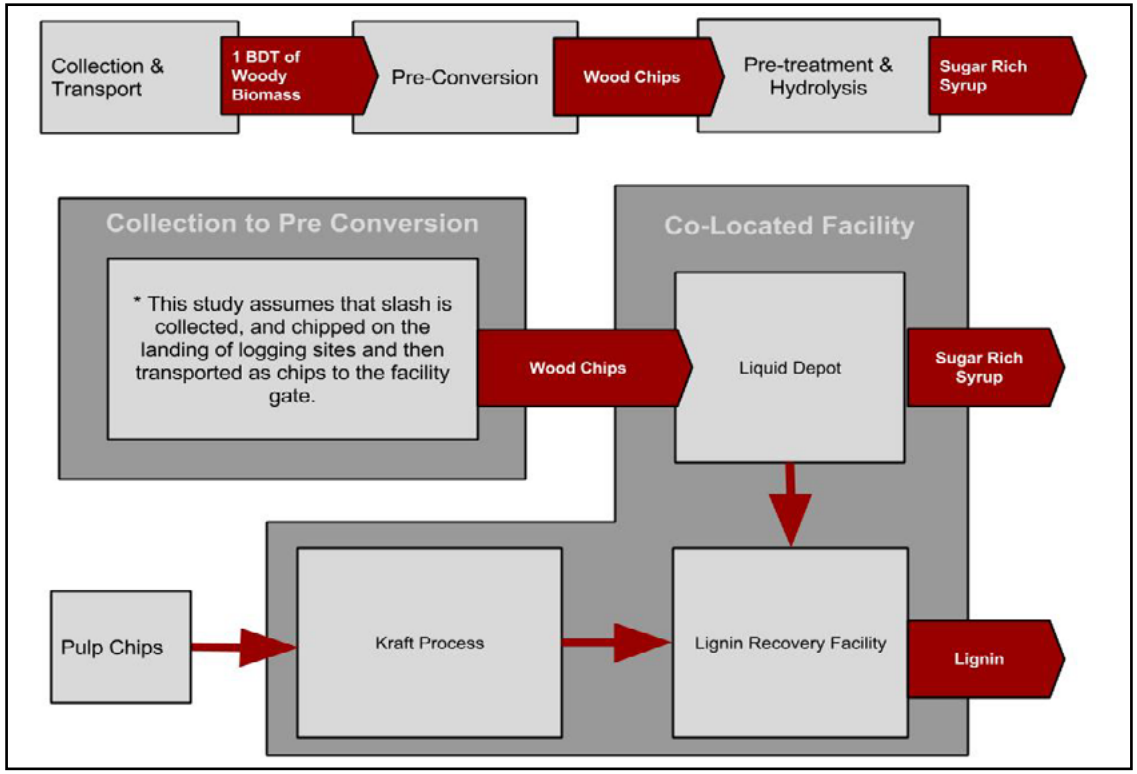

Figure 1.3.2. Illustration of the OP study objectives, depicting the co-locating of a liquids depot and lignin recovery facility at Port Townsend Paper Corporation and Nippon

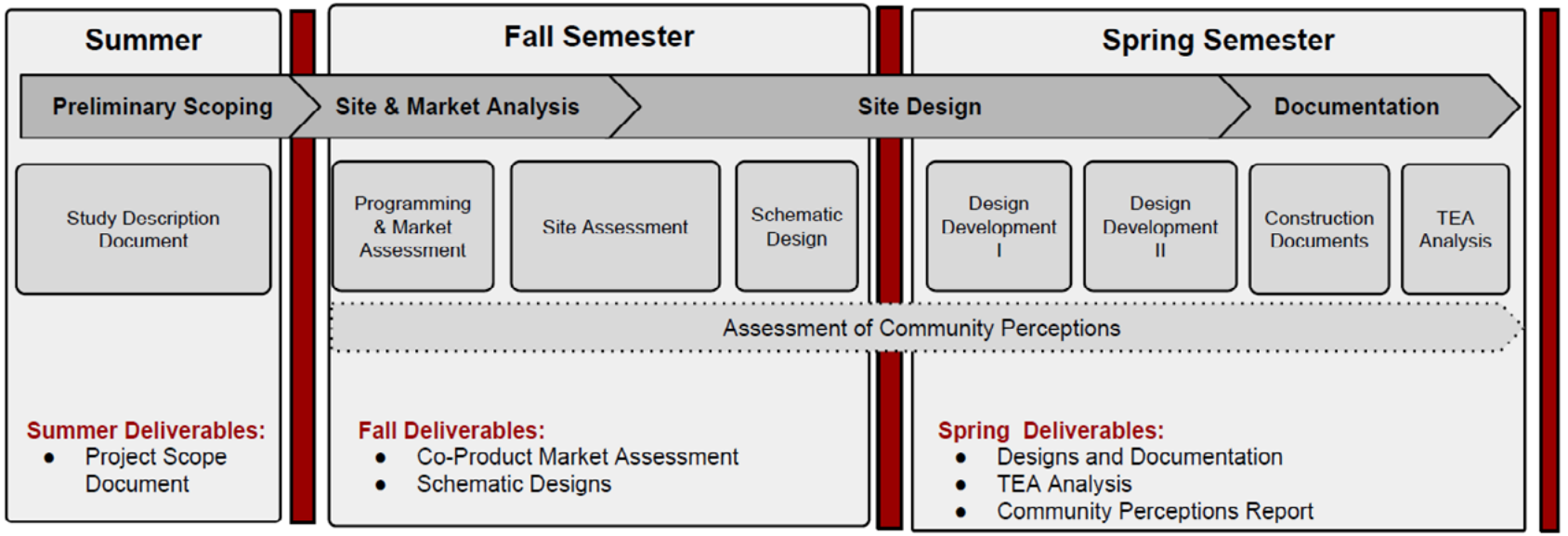

Figure 1.3.3. IDX Structure and OP Liquids Depot & Co-Products Study Stages

1.3.2 OLYMPIC PENINSULA STUDY SCHEDULE

The OP liquids depot and co-products study is divided into four stages (see Figure 1.3.3): 1) Preliminary Scoping, 2) Site and Market Analysis, 3) Site Design, and 4) Documentation.

Preliminary Scoping

Stage one describes the regional supply chain opportunities on the Olympic Peninsula. This Preliminary Scoping document defines objectives, roles of collaborators, and approach.

Site and Market Analysis

IDX will examine the opportunity for liquids depots to be co-located at PTPC and Nippon and assess market opportunities for liquid sugars and lignin co-products. Following the site analysis, programming, site assessment and schematic designs will follow.

- Programming clarifies the scope of work, on-site operations, facility needs, and cost estimates for a liquids depot.
- Site assessment examines a specific site's opportunities and constraints for development based on existing site assets and potential liabilities.
- Schematic design demonstrates basic spaces, scale and the relationship of components as they relate to environmental economic and social impacts of the proposed facility. The secondary objective is to clarify the project program, explore the most promising alternative design solutions, and provide a reliable basis for analyzing the cost of the project. Multiple schematic design options are developed for each site, each including the sizing of buildings and processing areas and the flow of the site.

The market analysis will examine existing and potential markets for liquid sugars, which can be used to make biofuels and biobased plastics, and lignin that can be converted into 1) activated carbon products, 2) cement additives, and 3) polymeric resins.

Site Design

Site design commences once the preferred elements of the schematic designs have been selected. The site design for each liquids depots includes a design development phase, which focuses on the technical aspects of materials and infrastructure systems. Although this phase allows the designer to further refine space and function, the primary goal is to enable the site owner to understand how the project will function as well as give more detail about what the design will look like. Design development is an iterative process as designs are reviewed by the client and other stakeholders.

Documentation

Construction documents include all building and site plans, specifications, and supporting documents used during the completion of a construction project. The documents translate the needs of the owner or developer into a buildable format that can be universally understood within the construction industry. Preliminary construction documents will be drafted by IDX. There preliminary designs will include major design decisions for site layout, new or modified buildings, space delineation in buildings, layout of all processing equipment including supporting calculations upon which stakeholders may build upon further.

A techno-economic analysis (TEA) will provide estimated site costs. The TEA will focus on the capital costs necessary to implement the site design and the operational costs to run the facility on an annual basis.

Community Perceptions

IDX will collaborate with WSU Extension faculty to identify community leaders that represent various stakeholders in the region. Through regional stakeholder meetings, IDX will assess community perceptions and concerns of wood-based biofuels production on the Olympic Peninsula. This assessment will mirror more extensive surveys and interviews conducted in the four-state region previously by NARA research groups; thus, it will complement existing data collected about stakeholder knowledge and perceptions.

Deliverables

Deliverables of the OP study will include:

- Preliminary Scoping Report
- Site and Market Analysis Report
- Site Design and Documentation Report
- Community Perceptions Report

1.4.0 REFERENCES

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