Bioenergy Inventory and Assessment for Eastern Washington

A Collaborative Project between the
Department of Ecology, INTEC, and Washington State University
Department of Biological Systems Engineering

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EXECUTIVE SUMMARY

PROJECT RESULTS

Washington State University, the Department of Ecology, and INTEC recently completed a Phase 1 project aimed at assessing Eastern Washington's twenty counties for available biomass and calculating the potential energy production of the biomass via anaerobic digestion. Twenty-four organic resource or waste types in 6 material categories were evaluated. The final numbers reflect the project's goal for determining the overall availability and potential, while reserving collection concerns and net energy, sensitivity, and economic analyses for a later Phase II study. Results of the assessment show that Eastern Washington has an annual production of 4.3 million tons of underutilized dry biomass, which is capable of producing, via anaerobic digestion and subsequent biogas conversion, 35 trillion BTU's of heat convertible to 3 trillion W hrs of electrical energy, which is equivalent to around 40% of Eastern Washington's annual residential electrical consumption. [1] In addition, digestion of the biomass will help mitigate environmental concerns brought about by present practices through nutrient cycling, odor reduction, water and air quality improvement, and greenhouse gas reduction.

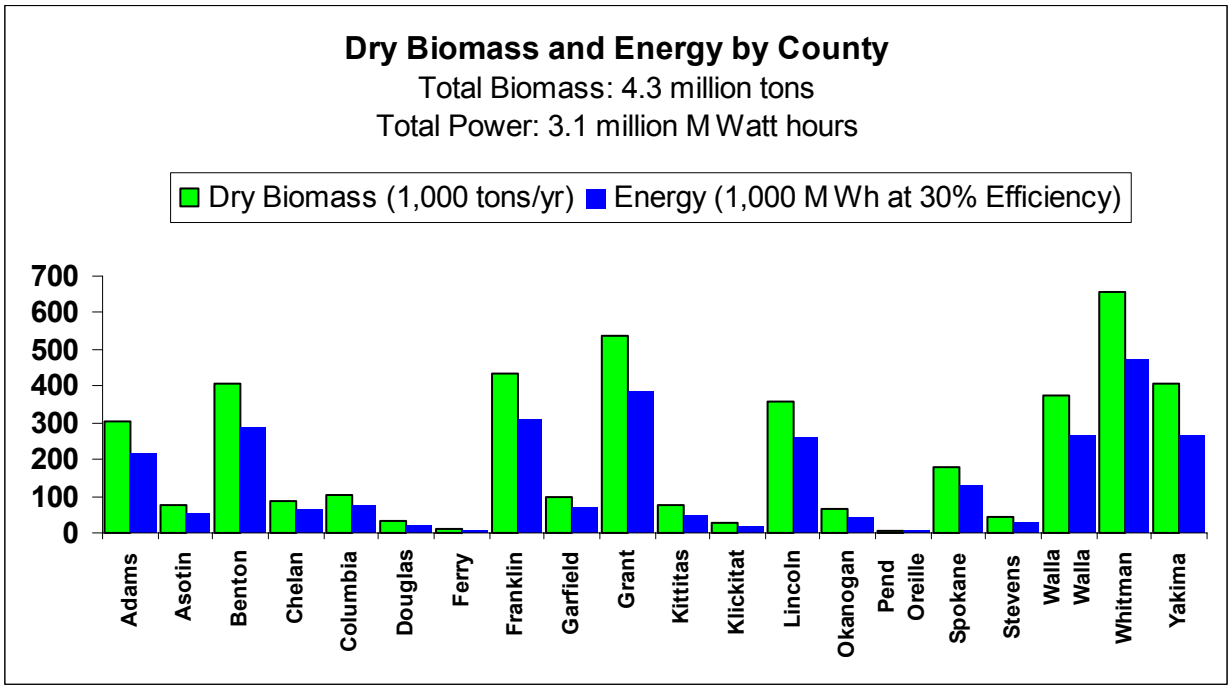

Table 1. Dry Biomass and Energy by County

[1] Washington Office of Fiscal Management and the US Energy Information Administration at http://www.eia.doe.gov/emeu/states/sep_use/res/use_res_wa.html.

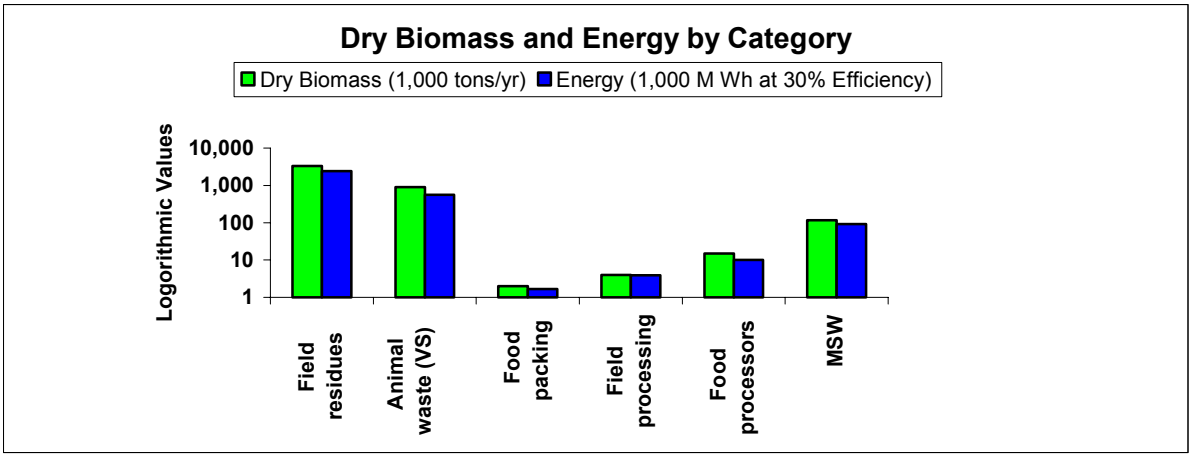

Table 2. Dry Biomass and Energy by Category

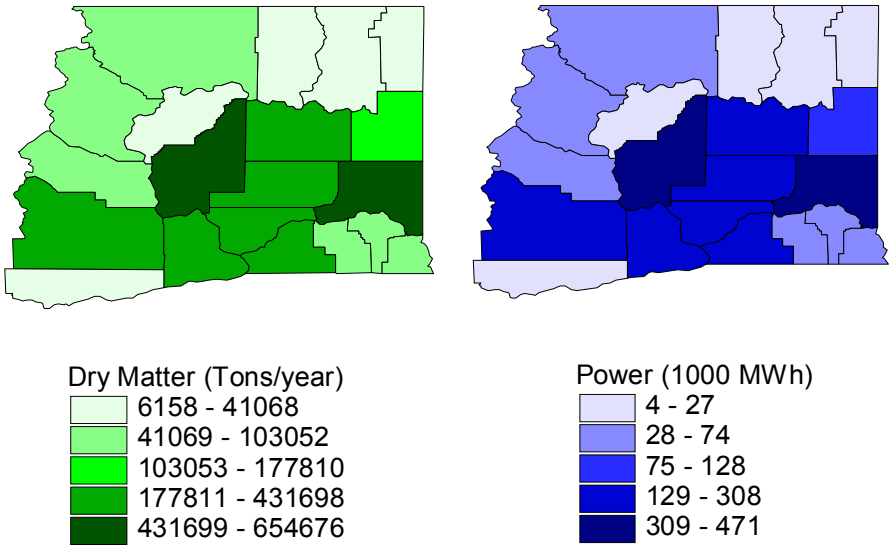

Figure 1. Distribution of Biomass and Energy by County

Analysis of the data indicates that the biomass is broadly distributed across all counties and occurs in both municipal and agricultural settings. However, the agricultural biomass is concentrated, with over 50% of the total represented predominantly in the top 5 counties of Whitman, Grant, Franklin, Benton, and Yakima. Food processor surveys and local knowledge indicate that waste resource concentrations also occur in specific sub-county locations that the report estimation techniques and broad data collection methods did not identify. These combined concentration factors enhance the possibility of effectively using the biomass in future local and regional bioenergy conversion facilities.

Although Eastern Washington has vast biomass resources running across all six key categories, it is field residue and animal waste on a total basis that overshadow the contributions from the other categories, comprising 97% of the inventoried biomass resource. Municipal waste systems are well established to collect organic resources and concentration does occur in current waste processing systems. This organic resource concentration may provide optimum potential for bioenergy utilization in the municipal sector.

Through the combined collaborative effort of the WSU research team, and the staff at INTEC and Ecology, this report demonstrates that vast biomass energy is present in the region. It is our common goal, that the data from this county-level, six category wide assessment will provide the basis to procure funding for a Phase II project. Phase II will be aimed at completing a state-wide inventory and assessment and expanding the assessment to include wood waste and additional agricultural organics as well as to include economic, transportation, and infrastructure analyses designed to more accurately apply these potential biomass energy results to commercial biomass development projects.

BACKGROUND

Growing Energy and Environmental Initiatives

Recognizing the growing concerns for energy supply and demand, reliance on foreign sources of energy, global climate change, and other ecological disruptions, President Bush in 2001, steered the nation towards an aggressive National Energy Policy focused on "promoting innovation and technology" specifically geared towards "diversifying America's supply of all sources of energy."[2]

Echoing this concern and belief regionally, Governor Gary Locke in his Natural Resources Spotlight stated, "As Washington's population grows and pressures on the environment increase, we must find new, innovative ways to protect and improve our precious natural resources [by] find[ing] ways to use the wealth of our forests, farmlands, and waters and still protect them for generations to come." [3]

Building upon this vision, the Governor's Sustaining Washington Advisory Panel in their 2003 submission to Governor Locke stated that the overall vision for Washington State should be "to achieve a fully sustainable Washington within one generation" proposing that benchmarks be achieved through such concepts as "reliance on renewable energy, no waste, and enduring natural resources."[4]

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[2] May 17, 2001 National Energy Policy speech in St. Paul, Minnesota http://www.whitehouse.gov/news/releases/2002/02/climatechange.html.)

[3] Governor Locke's webpage entitled Governor Locke's Natural Resources Spotlight at http://www.governor.wa.gov/nature/natural.htm.

[4] Governor's Sustained Washington Advisory Panel. 2003. A New Path Forward: Action Plan for a Sustainable Washington—Achieving Long-Term Economic, Social and Environmental Vitality, Feb.

Biomass as a renewable energy

Tables 3 and 4 below show the present state of renewable energy use in the US and Washington State.[5]

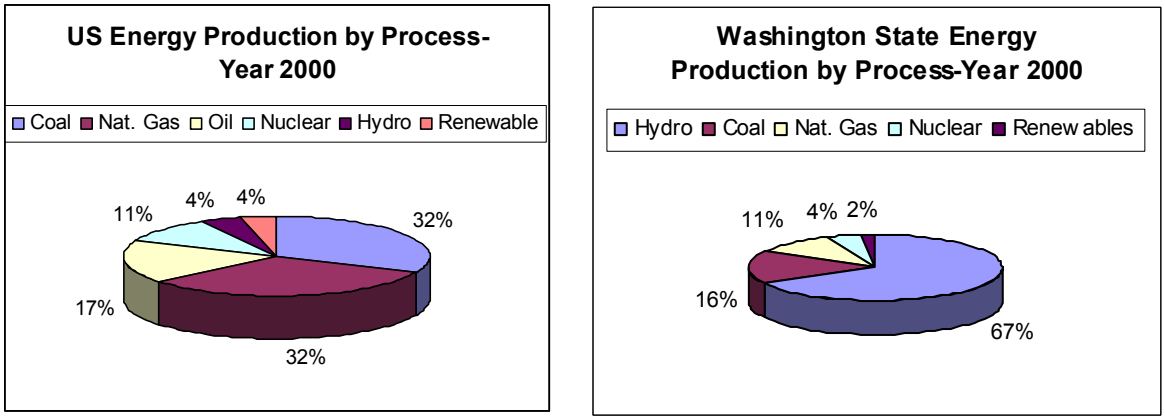

Table 3-4. US and Washington State Energy Production by Process for Year 2000

Over 80% of the national energy production and 27% of the state total are from fossil fuels with renewable energy sources at the lower end of the spectrum with 4% and 2%, respectively. Renewable energy represents a variety of sources including wind, solar, biomass, and geothermal. Nationally for the year 2000, though, over half of the renewable energy produced was in the form of biomass, although almost two-thirds of that biomass was from wood and wood waste while only 5% was from agricultural, municipal, or food processing waste. Given this small agricultural percentage it is apparent that this carbon-neutral biomass has great potential for increased development, particularly in Washington State. It is estimated that nationally and annually there are 512 million dry tons of biomass available for renewable energy with only 74 million tons currently being utilized.[6] A large percentage of this untapped biomass is right here in Washington State with its vast forests and its 8th and 23rd place ranking in national crop and livestock production as well as its top 10 production in 36 differing commodities.[7]

Anaerobic Digestion as a biomass energy technology

Biomass can be converted to power, fuels, or chemical feedstock. For purposes of this report, though, only technologies leading to the production of direct power such as heat and electricity were considered. Several technologies are available for converting biomass into electricity or heat. These include direct combustion, gasification/pyrolysis, and anaerobic digestion. Four factors are important in determining which process is most advantageous; type of biomass being used (i.e. high moisture), type of energy produced (i.e. heat or electricity), conversion efficiency, and waste products produced during the conversion. Table 5 below gives a brief summary of how the three main conversion processes compare in terms of key factors. Although anaerobic digestion has a rather low conversion efficiency when compared to the other two processes, it is

[5] Washington Department of Community Trade and Economic Development (2000) and the US Energy Information Administration (2000).

[6] Oak Ridge National Laboratories-Bioenergy. (1999). http://bioenergy.ornl.gov/papers/misc/resource_estimates.html

[7] Washington Agricultural Statistics Service (2003). http://www.nass.usda.gov/wa/ssoinfo.htm

particularly adept at converting wet biomass to energy while at the same time assisting in abetting the existing environmental concerns.

Table 5. Comparison of Energy Conversion Processes for Biomass

Process	Requirements	Products	Environmental Impact
Combustion	Dry, high moisture reduces the efficiency	Heat or power from the heat.	SO_2, SO_3, NO, NO_2, CO, Ash
Pyrolysis/ Liquefaction/ Gasification	Dry biomass is preferred.	Chars, liquid and gaseous fuels.	CO and Ash
Anaerobic Digestion	Primary feedstocks are organic wastes, including animal manure, human wastes, agriculture and food residue, and MSW	Heat, power, fuels, value-added chemicals	Post-processing waste has high nutrient value to crops, i.e., high amount of N easily available for crop uptake. Organic components in wastes are stabilized, pollution potential is reduced.

Anaerobic digestion is a technology that has been around for many years, but has only until recently begun to gain interest and favor as a responsible and effective means for producing energy from biomass. Recent technological advances improving digestion, reactor size, cost, and gas production along with federal and state tax incentives, increased concern for environmental issues, growth in waste streams from increasing human and livestock farm populations, and recent energy shortages caused in part by reliance on foreign oil are some of the reasons for the increased interest and cost effectiveness, which are spurring renewed interest from industry and academia.

Need for a biomass and bioenergy inventory

At present, very little information exists about the form, amount, and location of the nation's biomass, although interest and funding have recently produced three interesting surveys. Oak Ridge National Laboratories (ORNL) conducted a biomass and potential energy study down to the state level in 1999, but their study only included two agricultural sources, wheat and corn residue. The Hewlett and Energy Foundations sponsored a GIS inventory of western biomass with their 2002 study entitled "Renewable Energy Atlas of the West". Although their study considered a fewer number and different types of biomass categories, their energy totals are comparable to our results. Vermont initiated a 2000 report called "Vermont Methane Pilot Project—Resources Assessment", but this report did not bring the inventory down to the county level, nor did they address nearly as many biomass categories and sub-categories.

THE INVENTORY AND ASSESSMENT

Inventorying Washington's Biomass Resources

Inventorying Washington's bioresources is the first essential step for all related planning and implementation efforts. Information on types and geographic distribution of the biomass is critical for feasibility analysis and project prioritization. To that end, the consortium completed a

Phase 1 project to: (1) identify, categorize, and quantify the potential biomass sources, (2) geographically map the biomass sources at a county scale, and (3) calculate the potential energy production from those biomass sources via anaerobic digestion for all of eastern Washington. The sources included 24 different sub-categories within the six main categories of field residue, animal manure, food packing 'culls', field processing waste, food processing waste, and municipal solids.

Phase 1 protocol

A five-step method was used for calculating the potential power available from the anaerobic digestion of eastern Washington's underutilized biomass. First, agriculture and population censuses along with personal interviews with agriculture and processing leaders led to the development of a biomass inventory for the six main biomass categories. Second, the resulting biomass figures were adjusted according to their respective moisture content to represent dry matter numbers. The dry matter numbers were then converted to quantity of volatile solids (VS) using data from literature for each of the 24-biomass categories. During the fourth step, methane production values from assumed anaerobic digestion of the biomass were obtained from calculations upon the volatile solids and respective coefficients. Lastly, the methane values led to calculations of potential energy production for an average of typical conversion efficiencies (30 %).

Conclusions and Future Work

Table 6 below outlines how well the results arrived at in the biomass inventory and energy assessment will potentially meet Eastern Washington's energy needs. With standard transmission and usage losses taken into account, 39% and 15% of Eastern Washington's respective overall residential and residential electrical energy needs could be met. Those numbers jump to 73% and 42% respectively if transmittal and usage losses are not considered. If implemented and applied across the State, biomass energy could help Washington in achieving a sustainable economy and energy independence by both reducing our reliance on irreplaceable fossil fuels and aiding the environment through greenhouse gas reduction, odor abatement, and effective recycling of existing energy and nutrients.

Table 6. Residential Energy Statistics for Washington State [8]

	Overall Energy (trillion BTU)		Electrical Energy (trillion W hr)	
Inventory Result	35		3.1	
	Overall Energy (trillion BTU)		Electrical Energy (trillion W hr)	
	Without Loss	With Loss	Without Loss	With Loss
State Energy Totals (Yr. 2000)	217	410	33	90
Eastern Wash. (22% of total)	48	90	7.3	20
Consumption being met by biomass	35/48 = 73%	35/90= 39%	3.1/7.3 = 42%	3.1/20 = 15%

[8] US Energy Information Administration

In addition to energy and environmental gains, use of the biomass will lead directly to new jobs and an improved regional economy, particularly within rural areas. Presently across the US, power production from agricultural waste supports approximately 66,000 jobs. Seeing as the potential energy number from the Eastern Washington inventory is approximately equivalent to the present total annual US energy produced from biomass, this could potentially mean more jobs for citizens within rural Washington.[9]

Further research is needed, though, if this Phase I data is to be effective in helping the State build the infrastructure necessary to collect, transport, process, and convert the biomass to power that can be transmitted to the residents of the State. In particular, Phase II of the Project should include the following:

- Expand the study to a statewide basis and add biomass types and categories
- Improve data and references where possible
- Perform economic studies to assess infrastructure needs in collection, transportation, and processing of the biomass as well as investigate the role of by-products, market conditions, carbon market credits, and tax credits
- Assess the economic study outcomes using the BPA Transmission Grid Project

[9] Energy Efficiency and Renewable Energy Network (EERE). 2003. Webpage at http://www.eere.energy.gov/biopower/main.html.

INTRODUCTION

Washington State through its strong agriculture economy has a variety of agricultural residues, by-products, and waste material in addition to municipal organic resources that are excellent biomass sources with great potential for generating energy or producing products. For example, according to the US Department of Energy, it was estimated that 14.4 million MWh of electricity could be generated using renewable biomass in Washington, an amount that is enough to fully supply the annual needs of 1,443,000 average homes or 45% of the residential electricity use in the state.[10] Utilization of the biomass also creates environmental benefits, ranging from controlling greenhouse gas emission and reducing air quality impacts to protecting surface and ground water that may be adversely affected by management of these residues and wastes. Additionally, energy, soil amendments, and chemical production from biomass can contribute to the development of local economies.

Capitalizing on Washington's underutilized resources has attracted increasing interest. In their recently released document entitled "A new path forward: Action Plan for a Sustainable Washington", the Governor's Sustainable Washington Advisory Panel recommended "reliance on renewable energy", "no waste", and "enduring natural resources" as three of the eight essential strategic outcomes for 2030.[11] To realize these visions, the same panel recommended priority actions including investing in clean energy, committing to greenhouse gas reduction targets and mitigation strategies, and sustaining Washington's natural resources through collaborative efforts in planning, monitoring, protection, etc.

Conducting an inventory of Washington's bioresources is the first essential step for all related planning and implementation efforts. Information on types and geographic distribution of biomass is critical for feasibility analysis and project prioritization. The purpose of the project is to geographically map, identify, and categorize potential sources for convertible bioenergy in eastern Washington. The sources include field residues, animal manures, food packing 'culls', field processing waste, food processing waste, and municipal biosolids and solid wastes in each of the 20 counties in eastern Washington. The products of the project include a computer database and this report. This project is the most comprehensive effort to date on bioenergy source inventory and analysis in Eastern Washington. The data will be of great value for a wide-range of users.

We chose to emphasize anaerobic digestion of these organic resources because the process is stable and is well understood. Anaerobic digestion yields energy in the form of methane that is directly combustible for heat and convertible to electrical power through standard generator design, provides potential for secondary co-generation projects, and creates an excellent organic amendment to stabilize soils and provide crop nutrients.

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[10] The Biomass Research and Development Initiative document *Washington-Biobased Fuels, Power, and Products State Fact Sheet*, December 2001.

[11] *A New Path Forward: Action Plan for a Sustainable Washington-Achieving Long-Term Economic, Social, and Environmental Vitality*, Submission by Governor Gary Locke to the Sustainable Washington Advisory Panel, February 2003.

This project is a collaborative effort between the Washington Department of Ecology (DOE), INTEC, and Washington State University (WSU), with DOE and INTEC providing the funding and WSU performing the work. During the course of the project, Mr. Mark Fuchs of the Department of Ecology provided technical assistance, and Ms. Julie Wallman of INTEC helped with project coordination. The project team thanks the cooperation from agencies, organizations, commodity groups and producers for providing data and related information that made the inventory and assessment possible.

HIGHLIGHTS AND METHODOLOGIES

A five-step method was used for calculating the potential energy available from the anaerobic digestion of Eastern Washington's underutilized biomass. First, agriculture and population censuses along with personal interviews with agriculture and processing leaders led to the development of a county-by-county biomass inventory. This inventory covered 6 key areas of biomass production prevalent in Washington State: field residue, animal waste, food packing 'culls', field processing waste, food processing waste, and municipal waste including biosolids from wastewater treatment. Second, the resulting biomass figures were adjusted according to their respective moisture content to represent dry matter numbers. The dry matter numbers were then converted to quantity of volatile solids (VS) present using individual data from literature for each of the 24-biomass categories. During the fourth step, methane production values from assumed anaerobic digestion of the biomass were obtained directly from calculations based upon the volatile solids and respective coefficients. Lastly, the methane values led to calculations of potential heat and energy production for an average range of typical conversion efficiencies (30 %). This phase of the assessment aggregated total biomass inventory by type of material for the county. Individual biomass project location and feasibility were left to a next phase and were not evaluated in this report.

Final compilation of the data shows that Eastern Washington, alone, produces over 4.3 million tons of dry matter biomass available for bioenergy projects. If this annual biomass production were to be collected and anaerobically digested, the corresponding methane gas production would be 33.4 billion ft^3, representing an energy potential of 35 trillion BTU's or 3 trillion W hrs of electrical energy. Washington State's overall 2000 residential electrical power consumption was 33 trillion W hours.[12] Since Eastern Washington's population is 1.33 million or 22% of the State's overall population, this total electrical energy consumption would correspond to 7.3 trillion W hrs for Eastern Washington.[13] Thus effective collection and anaerobic digestion of Eastern Washington's available biomass could potentially meet about 40% of Eastern Washington's residential electrical energy needs.

The county-level statistical data achieved and represented in the following tables are an important first step in calculating the state's overall biomass and corresponding hidden and underutilized energy assets. The tabulated data were obtained from crop production and processing statistics, telephone surveys, and estimates based on national per capita averages. Independent verification processes for each organic resource type are needed to provide

[12] http://www.eia.doe.gov/emeu/states/sep_use/res/use_res_wa.html
[13] http://www.ofm.wa.gov/pop/coseries/C60T02.xls

assurance and validation of organic materials estimates. Organic materials in municipal solid waste steams have been evaluated in several counties in the state. Municipal biosolids data are also available from wastewater treatment. These may provide more precise data for municipal organic resources.

Additional time and research will be needed if the existing data is to not only be extended to the entire state, but to be utilized also as a tool for recognizing future needs in transportation, storage, and processing of biomass. In particular, the study will have to expand the 24 categories to such items as cherries and miscellaneous vegetable processing as well as forest harvest and silvicultural resources. In addition, the inventory should be expanded to a sub-county level that will better represent ultimate transportation, storage and processing fates of the biomass.

This report provides references and discussions of assumptions, concerns, and sources used or developed for the project. These are presented in the Appendices to the report. A more complete presentation of all of the data, tables, and figures can be accessed using a supporting computer program which can be accessed at **http://www.ecy.wa.gov/biblio/0307021.htm**.

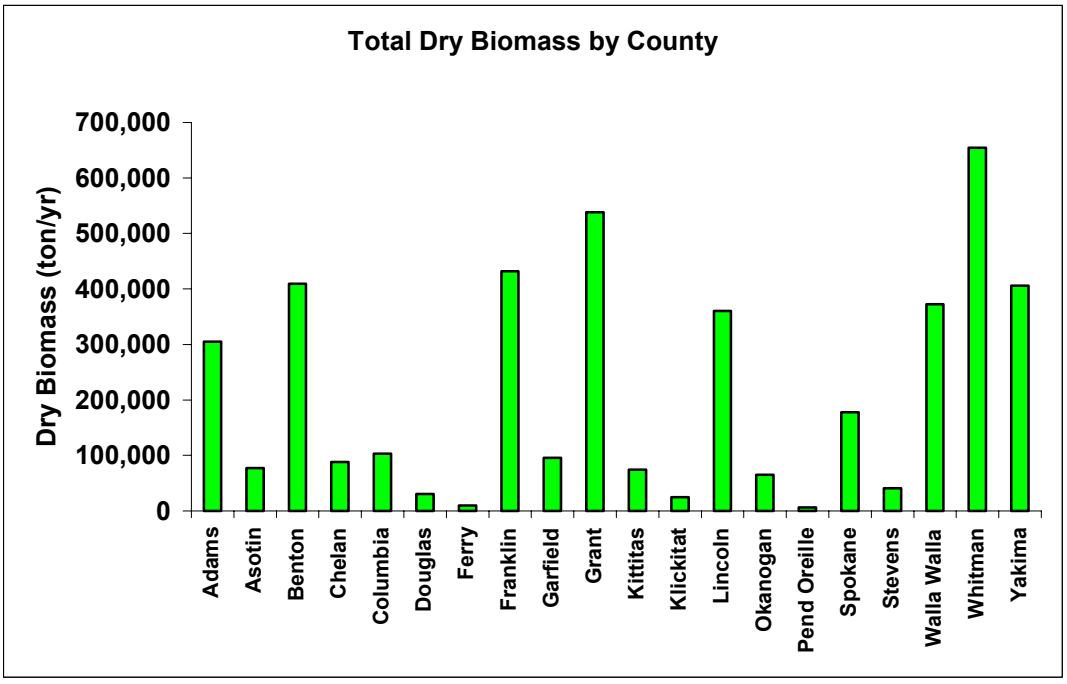
TABLES AND FIGURES

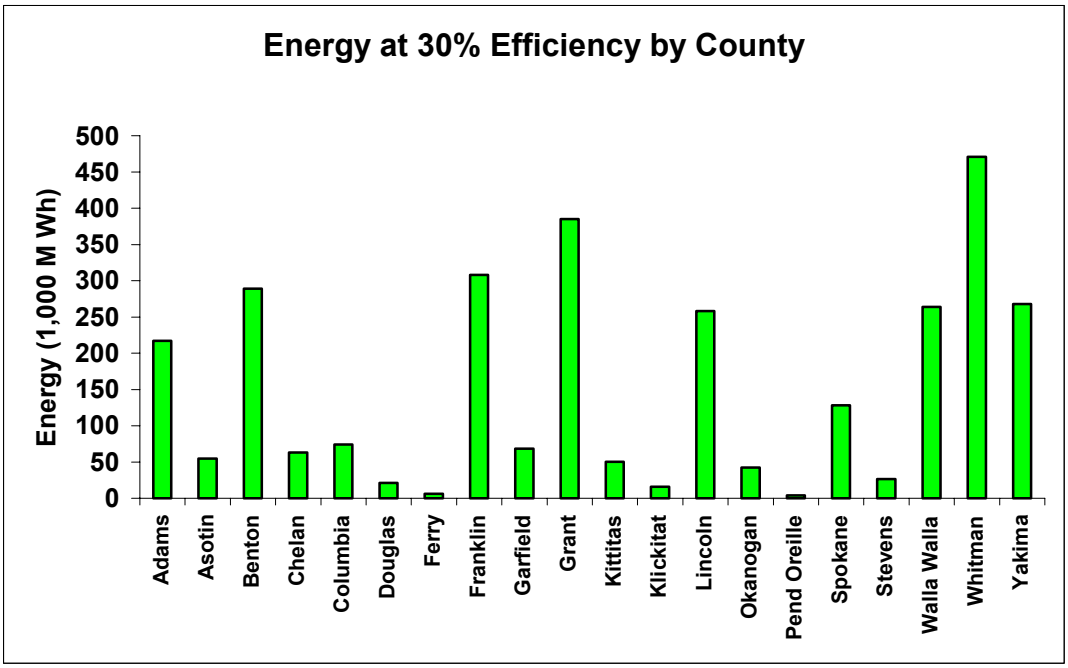
TOTAL BIOMASS AND BIOENERGY BY COUNTY

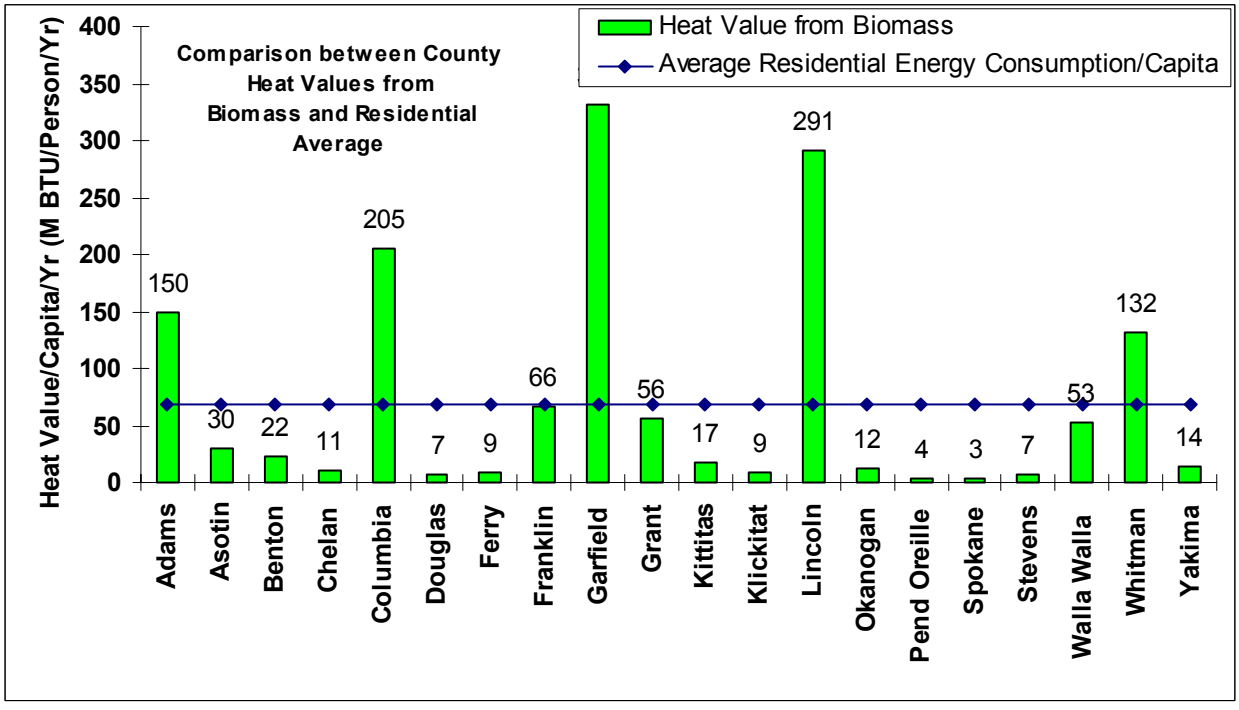
A. Table of Total Biomass and Bioenergy by County

Counties	Biomass (dry)	Methane	Heat Value	Energy (1,000 M Wh)
	Tons/yr	M cu. ft	M Btu	at 30% Efficiency
Adams	305,095	2,356	2,469,995	217
Asotin	77,296	593	621,603	54.6
Benton	409,341	3,143	3,293,925	289
Chelan	87,862	681	713,567	62.8
Columbia	103,052	803	841,023	74.2
Douglas	30,680	228	238,828	21.0
Ferry	9,504	65	67,803	5.97
Franklin	431,698	3,342	3,502,581	308
Garfield	95,826	737	772,105	68.4
Grant	538,019	4,180	4,382,541	385
Kittitas	74,534	547	572,832	50.4
Klickitat	25,006	171	179,081	15.8
Lincoln	360,118	2,800	2,934,670	258
Okanogan	65,019	459	480,885	42.2
Pend Oreille	6,158	42.6	44,605	3.93
Spokane	177,810	1,389	1,455,787	128
Stevens	41,068	288	301,897	26.6
Walla Walla	372,212	2,858	2,994,593	264
Whitman	654,676	5,118	5,362,930	471
Yakima	405,698	2,915	3,056,657	268
Others	71,161	712	745,719	65.5
Total	4,341,833	33,428	35,033,627	3,079

B. Figures of Total Biomass and Bioenergy by County




Energy at 30% Efficiency by County
Energy (1,000 M Wh)
500
450
400
350
300
250
200
150
100
50
0
Adams
Asotin
Benton
Chelan
Columbia
Douglas
Ferry
Franklin
Garfield
Grant
Kittitas
Klickitat
Lincoln
Okanogan
Pend Oreille
Spokane
Stevens
Walla Walla
Whitman
Yakima

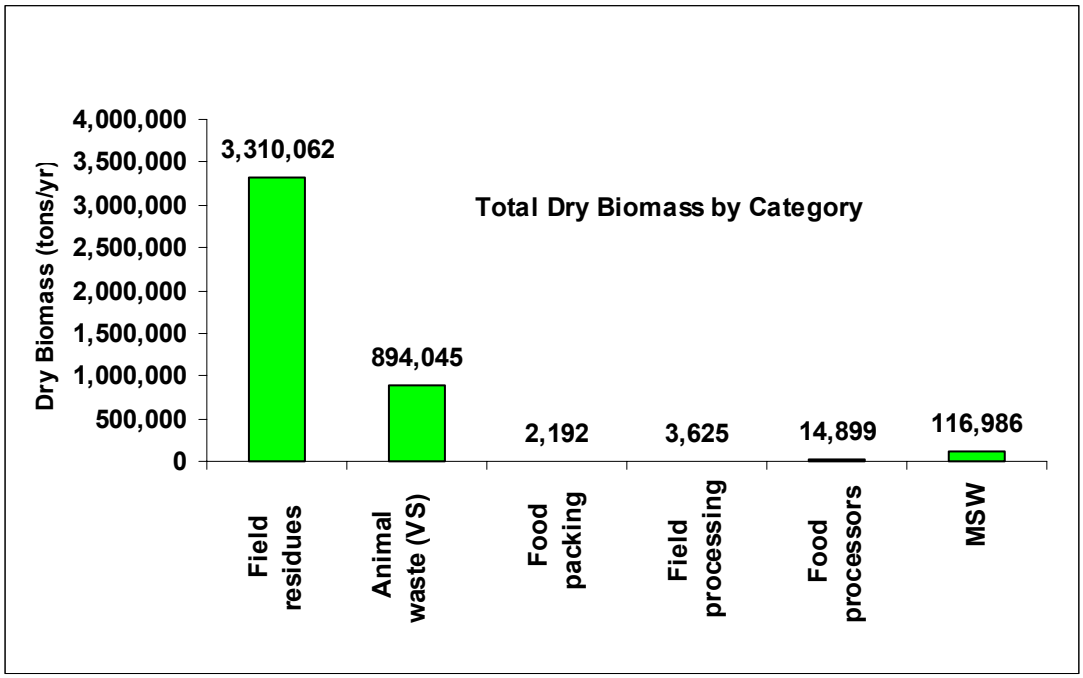

Heat Value from Biomass
Average Residential Energy Consumption/Capita
Comparison between County Heat Values from Biomass and Residential Average
Heat Value/Capita/Yr (M BTU/Person/Yr)
400
350
300
250
200
150
100
50
0
150
30
22
11
205
7
9
66
56
17
9
291
12
4
3
7
53
132
14
Adams
Asotin
Benton
Chelan
Columbia
Douglas
Ferry
Franklin
Garfield
Grant
Kittitas
Klickitat
Lincoln
Okanogan
Pend Oreille
Spokane
Stevens
Walla Walla
Whitman
Yakima

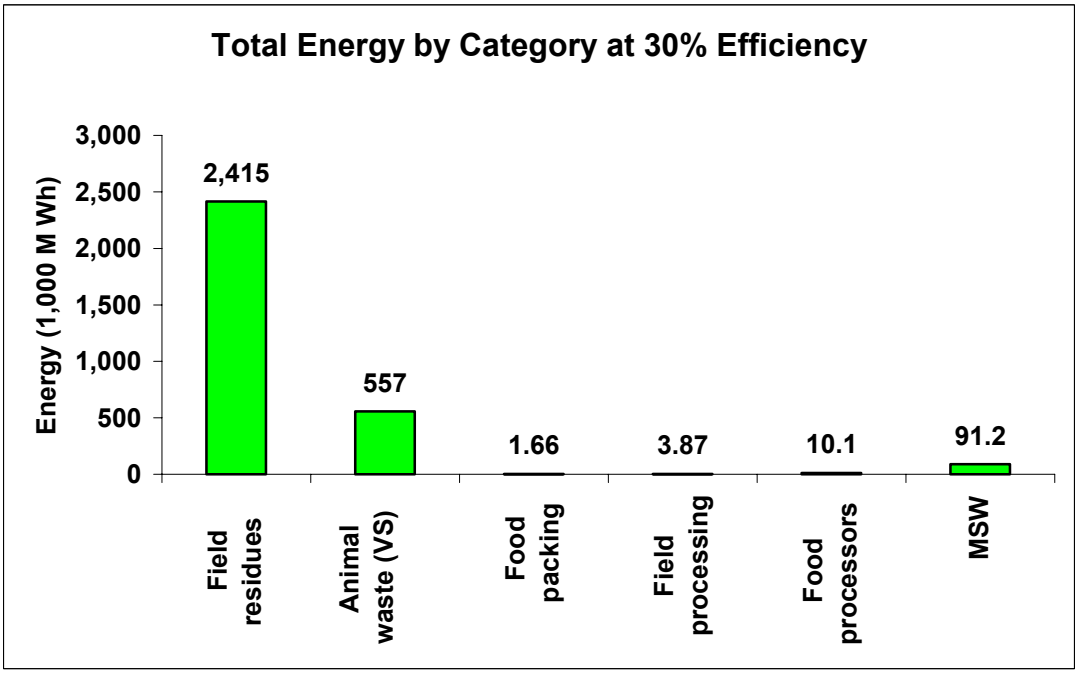
BIOMASS AND BIOENERGY BY CATEGORY

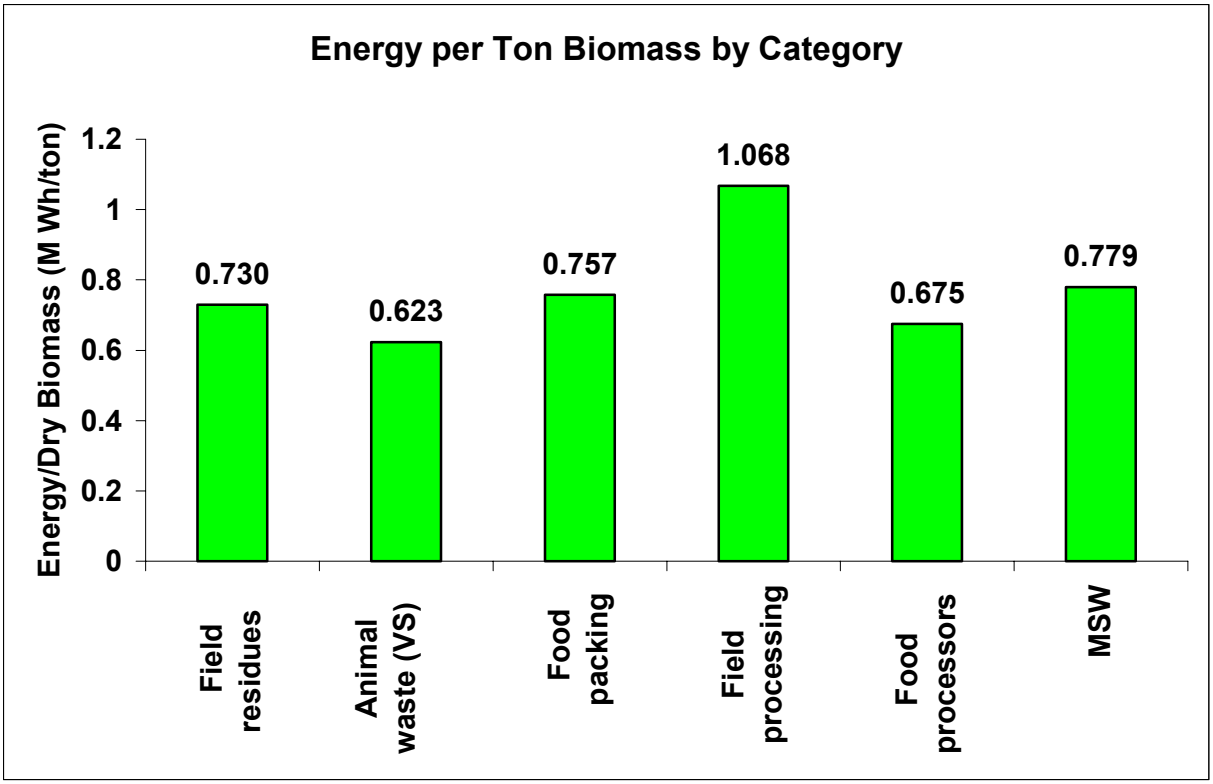
A. Table of Biomass and Bioenergy by Category per Year

Biomass and Bioenergy by Category	Biomass (dry)	Methane	Heat Value	Energy (1,000 M Wh)
Field residues	Tons/yr	M cu. ft	M Btu	at 30% Efficiency
Wheat straw	2,209,829	17,365	18,198,131	1,600
Bluegrass straw	31,223	144	150,729	13.3
Barley straw	913,109	7,092	7,432,094	653
Corn Stover	155,901	1,619	1,697,144	149
Subtotal	3,310,062	26,220	27,478,098	2,415
Animal waste (VS)				
Dairy manure	317,854	2,140	2,242,710	197
Cattle manure	568,036	3,824	4,007,928	352
Swine manure	5,387	57.0	59,725	5.25
Poultry manure	2,768	29.3	30,688	2.70
Subtotal	894,045	6,050	6,341,051	557
Food packing				
Cull onions	1,746	14.9	15,600	1.37
Cull potatoes	0	0	0	0
Cull apples	0	0	0	0
Asparagus butts	446	3.12	3,273	0.29
Subtotal	2,192	18.0	18,873	1.66
Field processing				
Mint slug	262	3.03	3,175	0.28
Hops	3,363	38.9	40,785	3.59
Subtotal	3,625	41.9	43,960	3.87
Food processors				
Asparagus	164	1.09	1,145	0.101
Apple pumace	12,268	85.2	89,281	7.85
Grape pumace	1,711	13.1	13,759	1.21
Berry pumace	1.01	0.0081	8.44	0.00074
Potato solids	755	9.80	10,267	0.90
Subtotal	14,899	109	114,460	10.1
Municipal Solid Wastes (MSW)				
Waste water treatment	30,970	246	257,538	22.6
Food waste	23,796	371	388,566	34.2
Yard debris				
Lawn clippings	8,780	51.8	54,316	4.78
Leaves	35,626	133	139,868	12.3
Other yard debris	13,361	56.4	59,057	5.19
Others				
Vegetable oils	944	27.9	29,229	2.57
Animal fats reclaimed	N/A	N/A	N/A	N/A
Glycol from airplane de-icing	3,509	104	108,611	9.55
Glycerol from biodiesel	N/A	N/A	N/A	N/A
Subtotal	116,986	990	1,037,185	91.2
TOTAL	4,341,809	33,430	35,033,627	3,079

B. Figures of Biomass and Bioenergy by Category







BIOMASS AND BIOENERGY BY BOTH COUNTY AND CATEGORY

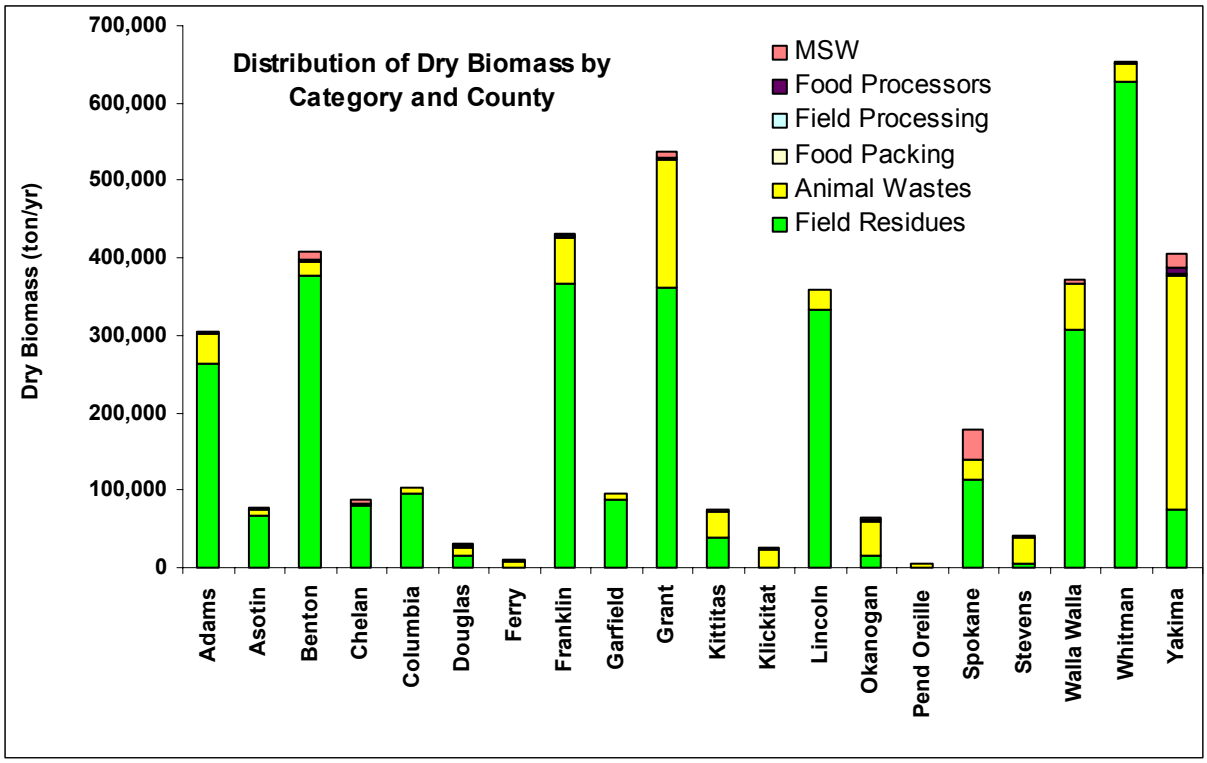
A. Table of Biomass by County and Category

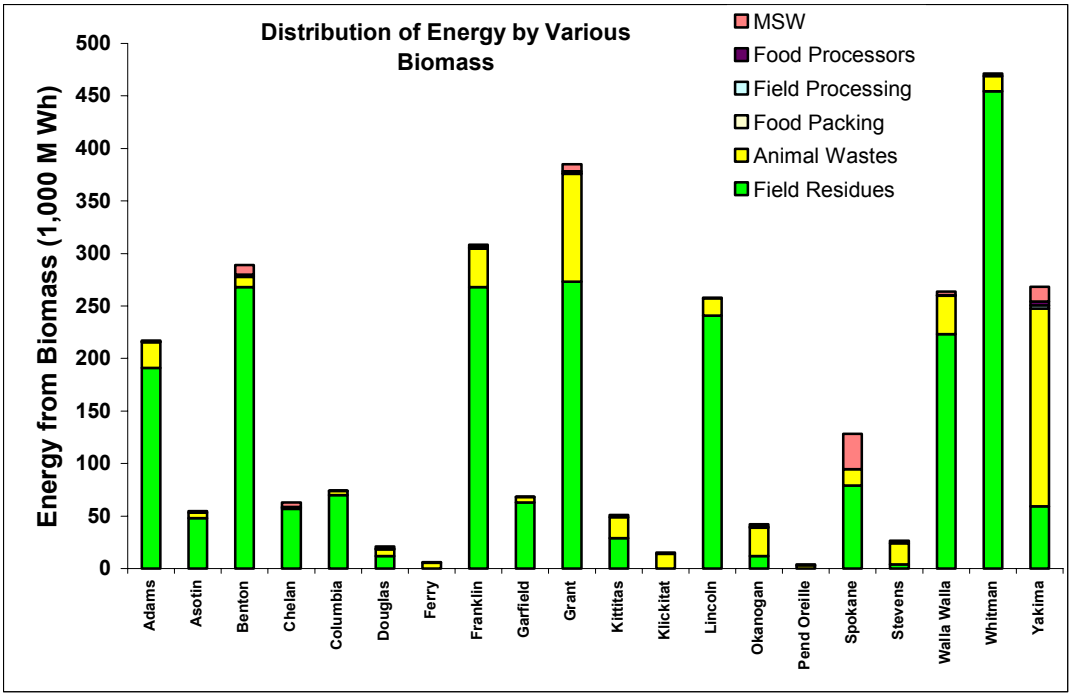
(in dry tons/yr)	Field Residue	Animal Waste	Food Packing	Field Proc.	Food Proc.	MSW
Adams	263,790	39,359	153	47.4	299	1,447
Asotin	67,162	8,292	0	0	0.72	1,842
Benton	378,364	15,649	356	673.0	1,685	12,614
Chelan	79,476	1,533	0	0	925	5,928
Columbia	96,328	6,383	0	0	0	341
Douglas	16,397	10,562	0	0	769	2,952
Ferry	0	8,854	0	0	0	650
Franklin	368,065	59,021	782	9.2	849	2,972
Garfield	87,143	8,476	0	0	0	207
Grant	361,740	165,469	605	100	2,781	7,324
Kittitas	39,902	31,570	0	1.50	155	2,906
Klickitat	0	23,260	0	0	36	1,710
Lincoln	332,958	26,264	0	0	32	864
Okanogan	16,470	43,821	0	0	1,266	3,462
Pend Oreille	0	5,112	0	0	0	1,046
Spokane	113,242	25,143	0	0	3.73	39,422
Stevens	5,437	32,079	0	0	0.289	3,552
Walla Walla	307,929	58,718	97	0	596.7	4,871
Whitman	628,894	22,266	0	0	0.55	3,515
Yakima	75,604	302,236	200	2,793	5,499	19,366

B. Table of Energy by County and Category

(in M W/hr)	Field Residue	Animal Waste	Food Packing	Field Proc.	Food Proc.	MSW
Adams	191	24.7	0.120	0.051	0.25	1.03
Asotin	48.1	5.14	0	0	0.00046	1.41
Benton	268	9.7	0.285	0.720	1.21	9.06
Chelan	57	1.0	0	0	0.59	4.28
Columbia	70	3.96	0	0	0	0.24
Douglas	11.8	6.58	0	0	0.49	2.11
Ferry	0	5.49	0	0	0	0.47
Franklin	268	36.7	0.58	0.010	0.64	2.40
Garfield	63	5.26	0	0	0	0.15
Grant	273	103	0.474	0.11	1.88	6.44
Kittitas	29	20	0	0.0016	0.10	2.09
Klickitat	0	14	0	0	0.030	1.25
Lincoln	241	16.4	0	0	0.038	0.60
Okanogan	11.8	27.2	0	0	0.810	2.46
Pend Oreille	0	3.1756	0	0	0	0.751
Spokane	79	15.7	0	0	0.00234	33.5
Stevens	3.94	20.029	0	0	0.000196	2.60
Walla Walla	223.27	36.500	0.073	0	0.4174	3.57
Whitman	454.4	14.43	0	0	0.00035	2.57
Yakima	59.4	188.1	0.139	2.98	3.578	14.19

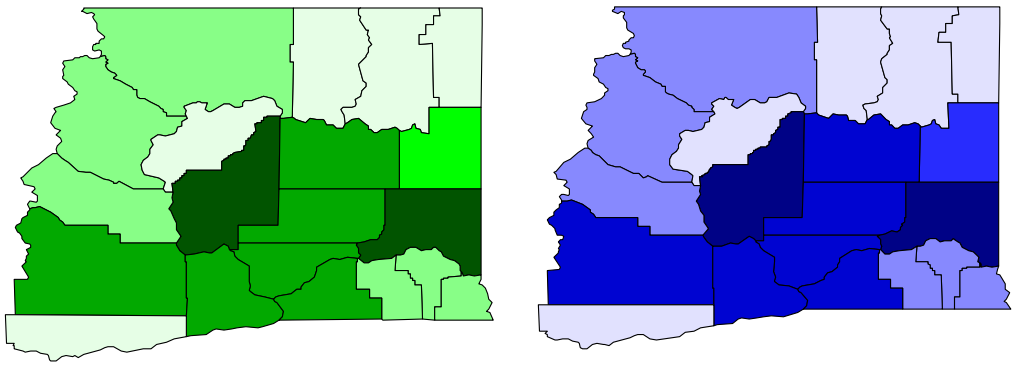
C. Figures of Biomass and Energy by County and Category





STATE VIEW OF DRY MATTER AND ENERGY TOTALS BY COUNTY

A. Figures representing state view of biomass and energy totals



Dry Matter (Tons/year)
- 6158 - 41068
- 41069 - 103052
- 103053 - 177810
- 177811 - 431698
- 431699 - 654676

Power (1000 MWh)
- 4 - 27
- 28 - 74
- 75 - 128
- 129 - 308
- 309 - 471

BIOMASS AND BIOENERGY COUNTY BY COUNTY

A. Tables of Biomass and Bioenergy County by County

County: Adams	Biomass (dry)	Methane	Heat Value	Energy (1,000 M Wh)
Field residues	Tons/yr	M cu. ft	M Btu	at 30% Efficiency
Wheat straw	236,483	1,858	1,947,458	171
Bluegrass straw	5,480	25.2	26,455	2.33
Barley straw	13,967	108	113,682	10.0
Corn Stover	7,860	81.6	85,564	7.52
Subtotal	263,790	2,073	2,173,159	191
Animal waste(Dry matter is VS)				
Dairy manure	17,516	118	123,590	10.9
Cattle manure	21,199	143	149,575	13.2
Swine manure	609	6.44	6,754	0.59
Poultry manure	34.7	0.367	385	0.034
Subtotal	39,359	268	280,304	24.7
Food packing				
Cull onions	138	1.17	1,231	0.11
Cull potatoes	0	0	0	0
Cull apples	0	0	0	0
Asparagus butts	15.1	0.106	111	0.0098
Subtotal	153	1.28	1,342	0.120
Field processing				
Mint slug	47.4	0.55	575	0.051
Hops	0	0	0	0
Subtotal	47.4	0.55	575	0.051
Food processors				
Asparagus	5.52	0.037	38.6	0.0034
Apple pomace	174	1.21	1,268	0.11
Grape pomace	0	0	0	0
Berry pomace	0	0	0	0
Potato solids	119	1.55	1,622	0.14
Subtotal	299	2.80	2,929	0.25
Municipal Solid Wastes (MSW)				
Waste water treatment	392	3.11	3,260	0.29
Food waste	306	4.77	5,003	0.44
Yard debris				
Lawn clippings	113	0.67	699	0.061
Leaves	459	1.72	1,800	0.16
Other yard debris	172	0.72	760	0.067
Others				
Vegetable oils	5.31	0.157	164	0.014
Animal fats reclaimed	N/A	N/A	N/A	N/A
Glycol from airplane de-icing	0	0	0	0
Glycerol from biodiesel	N/A	N/A	N/A	N/A
Subtotal	1,447	11.1	11,686	1.03
TOTAL	305,095	2,356	2,469,995	217

County: Asotin	Biomass (dry)	Methane	Heat Value	Energy (1,000 M Wh)
Field residues	Tons/yr	M cu. ft	M Btu	at 30% Efficiency
Wheat straw	5,344	42.0	44,008	3.87
Bluegrass straw	0	0	0	0
Barley straw	61,818	480	503,157	44.2
Corn Stover	0	0	0	0
Subtotal	67,162	522	547,165	48.1
Animal waste(Dry matter is VS)				
Dairy manure	0	0	0	0
Cattle manure	8,289	55.8	58,485	5.14
Swine manure	0	0	0	0
Poultry manure	2.62	0.028	29.1	0.0026
Subtotal	8,292	56	58,514	5.14
Food packing				
Cull onions	0	0	0	0
Cull potatoes	0	0	0	0
Cull apples	0	0	0	0
Asparagus butts	0	0	0	0
Subtotal	0	0	0	0
Field processing				
Mint slug	0	0	0	0
Hops	0	0	0	0
Subtotal	0	0	0	0
Food processors				
Asparagus	0	0	0	0
Apple pomace	0.72	0.0050	5.26	0.00046
Grape pomace	0	0	0	0
Berry pomace	0	0	0	0
Potato solids	0	0	0	0
Subtotal	0.72	0.0050	5.26	0.00046
Municipal Solid Wastes (MSW)				
Waste water treatment	486	3.86	4,041	0.36
Food waste	380	5.92	6,205	0.55
Yard debris				
Lawn clippings	140	0.83	868	0.076
Leaves	569	2.13	2,234	0.20
Other yard debris	214	0.90	944	0.083
Others				
Vegetable oils	52.6	1.55	1,627	0.143
Animal fats reclaimed	N/A	N/A	N/A	N/A
Glycol from airplane de-icing	0	0	0	0
Glycerol from biodiesel	N/A	N/A	N/A	N/A
Subtotal	1,842	15.2	15,919	1.41
TOTAL	77,296	593	621,603	54.6

County: Benton	Biomass (dry)	Methane	Heat Value	Energy (1,000 M Wh)
Field residues	Tons/yr	M cu. ft	M Btu	at 30% Efficiency
Wheat straw	0	0	0	0
Bluegrass straw	7,422	34.2	35,830	3.15
Barley straw	370,942	2,881	3,019,219	265
Corn Stover	0	0	0	0
Subtotal	378,364	2,915	3,055,049	268
Animal waste(Dry matter is VS)				
Dairy manure	4,609	31.0	32,522	2.86
Cattle manure	11,019	74.2	77,748	6.84
Swine manure	0	0	0	0
Poultry manure	21.3	0.225	236	0.021
Subtotal	15,649	105	110,506	9.7
Food packing				
Cull onions	348	2.96	3,106	0.28
Cull potatoes	0	0	0	0
Cull apples	0	0	0	0
Asparagus butts	7.60	0.053	55.8	0.0049
Subtotal	356	3.01	3,162	0.285
Field processing				
Mint slug	0	0	0	0
Hops	673	7.78	8,158	0.72
Subtotal	673.0	7.78	8,158	0.720
Food processors				
Asparagus	2.80	0.019	19.6	0.0017
Apple pomace	788	5.47	5,734	0.50
Grape pomace	727	5.58	5,846	0.51
Berry pomace	0	0	0	0
Potato solids	167	2.17	2,276	0.20
Subtotal	1,685	13.24	13,876	1.21
Municipal Solid Wastes (MSW)				
Waste water treatment	3,396	26.9	28,240	2.48
Food waste	2,659	41.4	43,419	3.82
Yard debris				
Lawn clippings	981	5.79	6,069	0.53
Leaves	3,981	14.9	15,629	1.37
Other yard debris	1,493	6.30	6,598	0.58
Others				
Vegetable oils	104	3.07	3,220	0.28
Animal fats reclaimed	N/A	N/A	N/A	N/A
Glycol from airplane de-icing	0	0	0	0
Glycerol from biodiesel	N/A	N/A	N/A	N/A
Subtotal	12,614	98.4	103,175	9.06
TOTAL	409,341	3,143	3,293,925	289

County: Chelan	Biomass (dry)	Methane	Heat Value	Energy (1,000 M Wh)
Field residues	Tons/yr	M cu. ft	M Btu	at 30% Efficiency
Wheat straw	0	0	0	0
Bluegrass straw	0	0	0	0
Barley straw	79,476	617	646,881	56.9
Corn Stover	0	0	0	0
Subtotal	79,476	617	646,881	57
Animal waste(Dry matter is VS)				
Dairy manure	0	0	0	0
Cattle manure	1,447	9.74	10,208	0.90
Swine manure	83.3	0.88	924	0.081
Poultry manure	2.72	0.029	30.1	0.0026
Subtotal	1,533	11	11,162	1.0
Food packing				
Cull onions	0	0	0	0
Cull potatoes	0	0	0	0
Cull apples	0	0	0	0
Asparagus butts	0	0	0	0
Subtotal	0	0.00	0	0.000
Field processing				
Mint slug	0	0	0	0
Hops	0	0	0	0
Subtotal	0.0	0.00	0	0.000
Food processors				
Asparagus	0	0	0	0
Apple pomace	925	6.43	6,734	0.59
Grape pomace	0	0	0	0
Berry pomace	0	0	0	0
Potato solids	0	0	0	0
Subtotal	925	6.43	6,734	0.59
Municipal Solid Wastes (MSW)				
Waste water treatment	1,593	12.6	13,247	1.16
Food waste	1,246	19.4	20,349	1.79
Yard debris				
Lawn clippings	460	2.71	2,844	0.25
Leaves	1,866	6.99	7,324	0.64
Other yard debris	700	2.95	3,093	0.27
Others				
Vegetable oils	62.5	1.84	1,933	0.17
Animal fats reclaimed	N/A	N/A	N/A	N/A
Glycol from airplane de-icing	0	0	0	0
Glycerol from biodiesel	N/A	N/A	N/A	N/A
Subtotal	5,928	46.5	48,790	4.28
TOTAL	87,862	681	713,567	62.8

County: Columbia	Biomass (dry)	Methane	Heat Value	Energy (1,000 M Wh)
Field residues	Tons/yr	M cu. ft	M Btu	at 30% Efficiency
Wheat straw	96,328	757	793,269	70
Bluegrass straw	0	0	0	0
Barley straw	0	0	0	0
Corn Stover	0	0	0	0
Subtotal	96,328	757	793,269	70
Animal waste(Dry matter is VS)				
Dairy manure	0	0	0	0
Cattle manure	6,383	43.0	45,035	3.96
Swine manure	0	0	0	0
Poultry manure	0	0	0	0
Subtotal	6,383	43	45,035	3.96
Food packing				
Cull onions	0	0	0	0
Cull potatoes	0	0	0	0
Cull apples	0	0	0	0
Asparagus butts	0	0	0	0
Subtotal	0	0	0	0
Field processing				
Mint slug	0	0	0	0
Hops	0	0	0	0
Subtotal	0	0	0	0
Food processors				
Asparagus	0	0	0	0
Apple pomace	0	0	0	0
Grape pomace	0	0	0	0
Berry pomace	0	0	0	0
Potato solids	0	0	0	0
Subtotal	0	0	0	0
Municipal Solid Wastes (MSW)				
Waste water treatment	93.0	0.74	773	0.068
Food waste	72.2	1.12	1,179	0.10
Yard debris				
Lawn clippings	26.7	0.16	165	0.015
Leaves	108	0.40	423	0.037
Other yard debris	40.6	0.17	179	0.016
Others				
Vegetable oils	0	0	0	0
Animal fats reclaimed	N/A	N/A	N/A	N/A
Glycol from airplane de-icing	0	0	0	0
Glycerol from biodiesel	N/A	N/A	N/A	N/A
Subtotal	341	2.6	2,719	0.24
TOTAL	103,052	803	841,023	74.2

County: Douglas	Biomass (dry)	Methane	Heat Value	Energy (1,000 M Wh)
Field residues	Tons/yr	M cu. ft	M Btu	at 30% Efficiency
Wheat straw	8,535	67.1	70,286	6.18
Bluegrass straw	0	0	0	0
Barley straw	7,862	61.1	63,991	5.63
Corn Stover	0	0	0	0
Subtotal	16,397	128	134,277	11.8
Animal waste(Dry matter is VS)				
Dairy manure	0	0	0	0
Cattle manure	10,468	70.5	73,857	6.49
Swine manure	93.7	0.99	1,039	0.091
Poultry manure	0	0	0	0
Subtotal	10,562	71.5	74,896	6.58
Food packing				
Cull onions	0	0	0	0
Cull potatoes	0	0	0	0
Cull apples	0	0	0	0
Asparagus butts	0	0	0	0
Subtotal	0	0	0	0
Field processing				
Mint slug	0	0	0	0
Hops	0	0	0	0
Subtotal	0	0	0	0
Food processors				
Asparagus	0	0	0	0
Apple pomace	769	5.34	5,598	0.49
Grape pomace	0	0	0	0
Berry pomace	0	0	0	0
Potato solids	0	0	0	0
Subtotal	769	5.34	5598	0.49
Municipal Solid Wastes (MSW)				
Waste water treatment	795	6.31	6,611	0.58
Food waste	623	9.71	10,173	0.89
Yard debris				
Lawn clippings	230	1.36	1,421	0.12
Leaves	933	3.50	3,663	0.32
Other yard debris	350	1.47	1,546	0.14
Others				
Vegetable oils	20.8	0.614	643	0.057
Animal fats reclaimed	N/A	N/A	N/A	N/A
Glycol from airplane de-icing	0	0	0	0
Glycerol from biodiesel	N/A	N/A	N/A	N/A
Subtotal	2,952	23.0	24,057	2.11
TOTAL	30,680	228	238,828	21.0

County: Ferry	Biomass (dry)	Methane	Heat Value	Energy (1,000 M Wh)
Field residues	Tons/yr	M cu. ft	M Btu	at 30% Efficiency
Wheat straw	0	0	0	0
Bluegrass straw	0	0	0	0
Barley straw	0	0	0	0
Corn Stover	0	0	0	0
Subtotal	0	0	0	0.0
Animal waste(Dry matter is VS)				
Dairy manure	0	0	0	0
Cattle manure	8,851	59.6	62,448	5.49
Swine manure	0	0	0	0
Poultry manure	2.87	0.030	31.8	0.0028
Subtotal	8,854	59.6	62,480	5.49
Food packing				
Cull onions	0	0	0	0
Cull potatoes	0	0	0	0
Cull apples	0	0	0	0
Asparagus butts	0	0	0	0
Subtotal	0	0	0	0
Field processing				
Mint slug	0	0	0	0
Hops	0	0	0	0
Subtotal	0	0	0	0
Food processors				
Asparagus	0	0	0	0
Apple pomace	0	0	0	0
Grape pomace	0	0	0	0
Berry pomace	0	0	0	0
Potato solids	0	0	0	0
Subtotal	0	0.00	0	0.00
Municipal Solid Wastes (MSW)				
Waste water treatment	175	1.39	1,455	0.13
Food waste	137	2.14	2,240	0.20
Yard debris				
Lawn clippings	50.6	0.30	313	0.028
Leaves	205	0.77	805	0.071
Other yard debris	77	0.32	340	0.030
Others				
Vegetable oils	5.49	0.162	170	0.015
Animal fats reclaimed	N/A	N/A	N/A	N/A
Glycol from airplane de-icing	0	0	0	0
Glycerol from biodiesel	N/A	N/A	N/A	N/A
Subtotal	650	5.1	5,323	0.47
TOTAL	9,504	65	67,803	5.97

County: Franklin	Biomass (dry)	Methane	Heat Value	Energy (1,000 M Wh)
Field residues	Tons/yr	M cu. ft	M Btu	at 30% Efficiency
Wheat straw	109,988	864	905,761	80
Bluegrass straw	2,286	10.5	11,036	0.97
Barley straw	239,268	1,858	1,947,481	171
Corn Stover	16,523	172	179,870	15.8
Subtotal	368,065	2,905	3,044,148	268
Animal waste(Dry matter is VS)				
Dairy manure	28,517	192	201,209	17.7
Cattle manure	30,322	204	213,944	18.8
Swine manure	182	1.93	2,020	0.18
Poultry manure	0	0	0	0
Subtotal	59,021	398	417,173	36.7
Food packing				
Cull onions	553	4.72	4,941	0.43
Cull potatoes	0	0	0	0
Cull apples	0	0	0	0
Asparagus butts	229	1.60	1,679	0.15
Subtotal	782	6.32	6620	0.58
Field processing				
Mint slug	9.2	0.11	111	0.010
Hops	0	0	0	0
Subtotal	9.2	0.11	111	0.010
Food processors				
Asparagus	84	0.56	588	0.052
Apple pomace	475	3.30	3,456	0.30
Grape pomace	118	0.91	949	0.083
Berry pomace	0.61	0.0048	5.07	0.00045
Potato solids	171	2.22	2,325	0.20
Subtotal	849	6.99	7323	0.64
Municipal Solid Wastes (MSW)				
Waste water treatment	1,178	9.35	9,796	0.86
Food waste	481	7.50	7,858	0.69
Yard debris				
Lawn clippings	178	1.05	1,098	0.097
Leaves	721	2.70	2,831	0.25
Other yard debris	270	1.14	1,194	0.11
Others				
Vegetable oils	49	1.44	1,504	0.13
Animal fats reclaimed	N/A	N/A	N/A	N/A
Glycol from airplane de-icing	95	2.79	2,925	0.26
Glycerol from biodiesel	N/A	N/A	N/A	N/A
Subtotal	2,972	26.0	27,206	2.40
TOTAL	431,698	3,342	3,502,581	308

County: Garfield	Biomass (dry)	Methane	Heat Value	Energy (1,000 M Wh)
Field residues	Tons/yr	M cu. ft	M Btu	at 30% Efficiency
Wheat straw	68,455	538	563,733	50
Bluegrass straw	1,566	7.2	7,560	0.66
Barley straw	17,122	133	139,362	12.3
Corn Stover	0	0	0	0
Subtotal	87,143	678	710,655	63
Animal waste(Dry matter is VS)				
Dairy manure	0	0	0	0
Cattle manure	8,476	57.1	59,806	5.26
Swine manure	0	0	0	0
Poultry manure	0	0	0	0
Subtotal	8,476	57	59,806	5.26
Food packing				
Cull onions	0	0	0	0
Cull potatoes	0	0	0	0
Cull apples	0	0	0	0
Asparagus butts	0	0	0	0
Subtotal	0	0	0	0
Field processing				
Mint slug	0	0	0	0
Hops	0	0	0	0
Subtotal	0	0	0	0
Food processors				
Asparagus	0	0	0	0
Apple pomace	0	0	0	0
Grape pomace	0	0	0	0
Berry pomace	0	0	0	0
Potato solids	0	0	0	0
Subtotal	0	0	0	0
Municipal Solid Wastes (MSW)				
Waste water treatment	56	0.44	466	0.041
Food waste	44	0.68	712	0.063
Yard debris				
Lawn clippings	16	0.10	100	0.0088
Leaves	66	0.25	258	0.023
Other yard debris	25	0.10	108	0.010
Others				
Vegetable oils	0	0	0	0
Animal fats reclaimed	N/A	N/A	N/A	N/A
Glycol from airplane de-icing	0	0	0	0
Glycerol from biodiesel	N/A	N/A	N/A	N/A
Subtotal	207	1.6	1,644	0.15
TOTAL	95,826	737	772,105	68.4

County: Grant	Biomass (dry)	Methane	Heat Value	Energy(1,000 M Wh)
Field residues	Tons/yr	M cu. ft	M Btu	at 30% Efficiency
Wheat straw	264,382	2,077	2,177,208	191
Bluegrass straw	0	0	0	0
Barley straw	46,891	364	381,661	33.6
Corn Stover	50,467	524	549,386	48.3
Subtotal	361,740	2,965	3,108,255	273
Animal waste(Dry matter is VS)				
Dairy manure	46,102	310	325,284	28.6
Cattle manure	117,996	794	832,551	73.2
Swine manure	1,366	14.5	15,148	1.33
Poultry manure	4.60	0.049	51	0.0045
Subtotal	165,469	1,119	1,173,034	103
Food packing				
Cull onions	567	4.84	5,069	0.45
Cull potatoes	0	0	0	0
Cull apples	0	0	0	0
Asparagus butts	38	0.27	278	0.024
Subtotal	605	5.11	5347	0.474
Field processing				
Mint slug	100	1.16	1,217	0.11
Hops	0	0	0	0
Subtotal	100	1.16	1217	0.11
Food processors				
Asparagus	13.9	0.093	97	0.0086
Apple pomace	2,504	17.4	18,225	1.60
Grape pomace	75	0.58	604	0.053
Berry pomace	0.0019	0.000015	0.016	0.0000014
Potato solids	188	2.43	2,550	0.22
Subtotal	2781	21	21476	1.88
Municipal Solid Wastes (MSW)				
Waste water treatment	1,815	14.4	15,093	1.33
Food waste	1,421	22.1	23,204	2.04
Yard debris				
Lawn clippings	524	3.10	3,244	0.29
Leaves	2,127	7.97	8,352	0.73
Other yard debris	798	3.37	3,527	0.31
Others				
Vegetable oils	3.15	0.093	97.5	0.0086
Animal fats reclaimed	N/A	N/A	N/A	N/A
Glycol from airplane de-icing	636	18.8	19,694	1.73
Glycerol from biodiesel	N/A	N/A	N/A	N/A
Subtotal	7,324	69.8	73,212	6.44
TOTAL	538,019	4,180	4,382,541	384.9

County: Kittitas	Biomass (dry)	Methane	Heat Value	Energy (1,000 M Wh)
Field residues	Tons/yr	M cu. ft	M Btu	at 30% Efficiency
Wheat straw	0	0	0	0
Bluegrass straw	0	0	0	0
Barley straw	39,902	310	324,775	28.6
Corn Stover	0	0	0	0
Subtotal	39,902	310	324,775	29
Animal waste(Dry matter is VS)				
Dairy manure	563	3.79	3,971	0.35
Cattle manure	30,922	208	218,178	19.2
Swine manure	79	0.84	877	0.077
Poultry manure	5.73	0.061	64	0.0056
Subtotal	31,570	213	223,090	20
Food packing				
Cull onions	0	0	0	0
Cull potatoes	0	0	0	0
Cull apples	0	0	0	0
Asparagus butts	0	0	0	0
Subtotal	0	0.00	0	0.000
Field processing				
Mint slug	1.50	0.017	18.2	0.0016
Hops	0	0	0	0
Subtotal	1.50	0.017	18.2	0.0016
Food processors				
Asparagus	0	0	0	0
Apple pomace	153	1.06	1,114	0.10
Grape pomace	0	0	0	0
Berry pomace	0	0	0	0
Potato solids	1.82	0.024	24.8	0.0022
Subtotal	155	1.08	1139	0.10
Municipal Solid Wastes (MSW)				
Waste water treatment	782	6.21	6,503	0.57
Food waste	612	9.54	9,997	0.88
Yard debris				
Lawn clippings	226	1.33	1,397	0.12
Leaves	916	3.43	3,597	0.32
Other yard debris	344	1.45	1,519	0.13
Others				
Vegetable oils	26	0.76	797	0.070
Animal fats reclaimed	N/A	N/A	N/A	N/A
Glycol from airplane de-icing	0	0	0	0
Glycerol from biodiesel	N/A	N/A	N/A	N/A
Subtotal	2,906	22.7	23,810	2.09
TOTAL	74,534	547	572,832	50.4

County: Klickitat	Biomass (dry)	Methane	Heat Value	Energy (1,000 M Wh)
Field residues	Tons/yr	M cu. ft	M Btu	at 30% Efficiency
Wheat straw	0	0	0	0
Bluegrass straw	0	0	0	0
Barley straw	0	0	0	0
Corn Stover	0	0	0	0
Subtotal	0	0	0	0
Animal waste(Dry matter is VS)				
Dairy manure	2,106	14.2	14,861	1.31
Cattle manure	21,074	142	148,692	13.1
Swine manure	73	0.77	808	0.071
Poultry manure	6.69	0.071	74	0.0065
Subtotal	23,260	157	164,435	14
Food packing				
Cull onions	0	0	0	0
Cull potatoes	0	0	0	0
Cull apples	0	0	0	0
Asparagus butts	0	0	0	0
Subtotal	0	0.00	0	0.000
Field processing				
Mint slug	0	0	0	0
Hops	0	0	0	0
Subtotal	0.00	0.000	0.0	0.0000
Food processors				
Asparagus	0	0	0	0
Apple pomace	14.2	0.10	104	0.0091
Grape pomace	13.3	0.10	107	0.0094
Berry pomace	0	0	0	0
Potato solids	8.8	0.11	120	0.011
Subtotal	36	0.31	331	0.03
Municipal Solid Wastes (MSW)				
Waste water treatment	456	3.62	3,792	0.33
Food waste	357	5.57	5,833	0.51
Yard debris				
Lawn clippings	132	0.78	815	0.072
Leaves	535	2.00	2,100	0.18
Other yard debris	201	0.85	886	0.078
Others				
Vegetable oils	28.7	0.85	889	0.078
Animal fats reclaimed	N/A	N/A	N/A	N/A
Glycol from airplane de-icing	0	0	0	0
Glycerol from biodiesel	N/A	N/A	N/A	N/A
Subtotal	1,710	13.7	14,315	1.25
TOTAL	25,006	171	179,081	15.8

County: Lincoln	Biomass (dry)	Methane	Heat Value	Energy (1,000 M Wh)
Field residues	Tons/yr	M cu. ft	M Btu	at 30% Efficiency
Wheat straw	332,708	2,614	2,739,879	241
Bluegrass straw	250	1.15	1,207	0.11
Barley straw	0	0	0	0
Corn Stover	0	0	0	0
Subtotal	332,958	2,615	2,741,086	241
Animal waste(Dry matter is VS)				
Dairy manure	0	0	0	0
Cattle manure	26,041	175	183,741	16.2
Swine manure	213	2.26	2,367	0.21
Poultry manure	9.85	0.104	109	0.0096
Subtotal	26,264	177	186,217	16.4
Food packing				
Cull onions	0	0	0	0
Cull potatoes	0	0	0	0
Cull apples	0	0	0	0
Asparagus butts	0	0	0	0
Subtotal	0	0	0	0
Field processing				
Mint slug	0	0	0	0
Hops	0	0	0	0
Subtotal	0	0	0	0
Food processors				
Asparagus	0	0	0	0
Apple pomace	0	0	0	0
Grape pomace	0	0	0	0
Berry pomace	0	0	0	0
Potato solids	32	0.42	437	0.038
Subtotal	32	0.42	437	0.038
Municipal Solid Wastes (MSW)				
Waste water treatment	235	1.86	1,954	0.17
Food waste	183	2.86	2,995	0.26
Yard debris				
Lawn clippings	68	0.40	418	0.037
Leaves	274	1.03	1,077	0.095
Other yard debris	103	0.43	455	0.040
Others				
Vegetable oils	0.99	0.029	30.6	0.0027
Animal fats reclaimed	N/A	N/A	N/A	N/A
Glycol from airplane de-icing	0	0	0	0
Glycerol from biodiesel	N/A	N/A	N/A	N/A
Subtotal	864	6.61	6,930	0.60
TOTAL	360,118	2,800	2,934,670	258

County: Okanogan	Biomass (dry)	Methane	Heat Value	Energy (1,000 M Wh)
Field residues	Tons/yr	M cu. ft	M Btu	at 30% Efficiency
Wheat straw	1,094	8.60	9,009	0.79
Bluegrass straw	0	0	0	0
Barley straw	15,376	119	125,150	11.0
Corn Stover	0	0	0	0
Subtotal	16,470	128	134,159	11.8
Animal waste(Dry matter is VS)				
Dairy manure	0	0	0	0
Cattle manure	43,743	295	308,637	27.1
Swine manure	62	0.66	693	0.061
Poultry manure	15.8	0.17	175	0.015
Subtotal	43,821	296	309,505	27.2
Food packing				
Cull onions	0	0	0	0
Cull potatoes	0	0	0	0
Cull apples	0	0	0	0
Asparagus butts	0	0	0	0
Subtotal	0	0	0	0
Field processing				
Mint slug	0	0	0	0
Hops	0	0	0	0
Subtotal	0	0	0	0
Food processors				
Asparagus	0	0	0	0
Apple pomace	1,266	8.79	9,215	0.81
Grape pomace	0	0	0	0
Berry pomace	0.0032	0.000025	0.027	0.0000023
Potato solids	0	0	0	0
Subtotal	1266	8.79	9215	0.810
Municipal Solid Wastes (MSW)				
Waste water treatment	936	7.43	7,784	0.68
Food waste	733	11.4	11,966	1.05
Yard debris				
Lawn clippings	270	1.60	1,672	0.15
Leaves	1,097	4.11	4,306	0.38
Other yard debris	411	1.73	1,818	0.16
Others				
Vegetable oils	14.9	0.44	460	0.040
Animal fats reclaimed	N/A	N/A	N/A	N/A
Glycol from airplane de-icing	0	0	0	0
Glycerol from biodiesel	N/A	N/A	N/A	N/A
Subtotal	3,462	26.71	28,006	2.46
TOTAL	65,019	459	480,885	42.2

County: Pend Oreille	Biomass (dry)	Methane	Heat Value	Energy (1,000 M Wh)
Field residues	Tons/yr	M cu. ft	M Btu	at 30% Efficiency
Wheat straw	0	0	0	0
Bluegrass straw	0	0	0	0
Barley straw	0	0	0	0
Corn Stover	0	0	0	0
Subtotal	0	0	0	0
Animal waste(Dry matter is VS)				
Dairy manure	0	0	0	0
Cattle manure	5,106	34.4	36,028	3.17
Swine manure	0	0	0	0
Poultry manure	5.73	0.061	64	0.0056
Subtotal	5,112	34.5	36,092	3.1756
Food packing				
Cull onions	0	0	0	0
Cull potatoes	0	0	0	0
Cull apples	0	0	0	0
Asparagus butts	0	0	0	0
Subtotal	0	0	0	0
Field processing				
Mint slug	0	0	0	0
Hops	0	0	0	0
Subtotal	0	0	0	0
Food processors				
Asparagus	0	0	0	0
Apple pomace	0	0	0	0
Grape pomace	0	0	0	0
Berry pomace	0	0	0	0
Potato solids	0	0	0	0
Subtotal	0	0.00	0	0
Municipal Solid Wastes (MSW)				
Waste water treatment	282	2.24	2,345	0.21
Food waste	221	3.44	3,605	0.32
Yard debris				
Lawn clippings	82	0.48	505	0.044
Leaves	330	1.24	1,297	0.11
Other yard debris	124	0.52	549	0.048
Others				
Vegetable oils	6.8	0.20	212	0.019
Animal fats reclaimed	N/A	N/A	N/A	N/A
Glycol from airplane de-icing	0	0	0	0
Glycerol from biodiesel	N/A	N/A	N/A	N/A
Subtotal	1,046	8.12	8,513	0.751
TOTAL	6,158	42.6	44,605	3.93

County: Spokane	Biomass (dry)	Methane	Heat Value	Energy (1,000 M Wh)
Field residues	Tons/yr	M cu. ft	M Btu	at 30% Efficiency
Wheat straw	102,197	803	841,601	74
Bluegrass straw	10,554	48.6	50,949	4.48
Barley straw	491	3.81	3,996	0.35
Corn Stover	0	0	0	0
Subtotal	113,242	855	896,546	79
Animal waste(Dry matter is VS)				
Dairy manure	5,570	37.5	39,303	3.46
Cattle manure	19,338	130	136,443	12.0
Swine manure	233	2.47	2,586	0.23
Poultry manure	1.74	0.018	19.2	0.0017
Subtotal	25,143	170	178,351	15.7
Food packing				
Cull onions	0	0	0	0
Cull potatoes	0	0	0	0
Cull apples	0	0	0	0
Asparagus butts	0	0	0	0
Subtotal	0	0	0	0
Field processing				
Mint slug	0	0	0	0
Hops	0	0	0	0
Subtotal	0	0	0	0
Food processors				
Asparagus	0	0	0	0
Apple pomace	3.4	0.023	24.5	0.0021
Grape pomace	0	0	0	0
Berry pomace	0.33	0.0026	2.71	0.00024
Potato solids	0	0	0	0
Subtotal	3.73	0.0256	27.21	0.00234
Municipal Solid Wastes (MSW)				
Waste water treatment	9,925	78.8	82,534	7.26
Food waste	7,767	121	126,867	11.2
Yard debris				
Lawn clippings	2,867	16.9	17,735	1.56
Leaves	11,632	43.6	45,667	4.02
Other yard debris	4,362	18.4	19,283	1.70
Others				
Vegetable oils	255	7.52	7,883	0.69
Animal fats reclaimed	N/A	N/A	N/A	N/A
Glycol from airplane de-icing	2,614	77	80,894	7.11
Glycerol from biodiesel	N/A	N/A	N/A	N/A
Subtotal	39,422	363.2	380,863	33.5
TOTAL	177,810	1,389	1,455,787	128

County: Stevens	Biomass (dry)	Methane	Heat Value	Energy (1,000 M Wh)
Field residues	Tons/yr	M cu. ft	M Btu	at 30% Efficiency
Wheat straw	5,437	43	44,774	3.94
Bluegrass straw	0	0	0	0
Barley straw	0	0	0	0
Corn Stover	0	0	0	0
Subtotal	5,437	43	44,774	3.94
Animal waste(Dry matter is VS)				
Dairy manure	4,930	33.2	34,784	3.06
Cattle manure	26,871	181	189,596	16.7
Swine manure	258	2.73	2,863	0.25
Poultry manure	19.8	0.21	220	0.019
Subtotal	32,079	217	227,463	20.029
Food packing				
Cull onions	0	0	0	0
Cull potatoes	0	0	0	0
Cull apples	0	0	0	0
Asparagus butts	0	0	0	0
Subtotal	0	0	0	0
Field processing				
Mint slug	0	0	0	0
Hops	0	0	0	0
Subtotal	0	0	0	0
Food processors				
Asparagus	0	0	0	0
Apple pomace	0.21	0.0015	1.54	0.00014
Grape pomace	0.065	0.00050	0.52	0.000046
Berry pomace	0.014	0.00011	0.12	0.000010
Potato solids	0	0	0	0
Subtotal	0.289	0.00211	2.18	0.000196
Municipal Solid Wastes (MSW)				
Waste water treatment	949	7.53	7,892	0.69
Food waste	743	11.6	12,136	1.07
Yard debris				
Lawn clippings	274	1.62	1,698	0.15
Leaves	1,112	4.17	4,367	0.38
Other yard debris	418	1.76	1,846	0.16
Others				
Vegetable oils	56	1.64	1,719	0.15
Animal fats reclaimed	N/A	N/A	N/A	N/A
Glycol from airplane de-icing	0	0	0	0
Glycerol from biodiesel	N/A	N/A	N/A	N/A
Subtotal	3,552	28.3	29,658	2.60
TOTAL	41,068	288	301,897	26.6

County: Walla Walla	Biomass (dry)	Methane	Heat Value	Energy (1,000 M Wh)
Field residues	Tons/yr	M cu. ft	M Btu	at 30% Efficiency
Wheat straw	307,302	2,415	2,530,658	223
Bluegrass straw	627	2.89	3,027	0.27
Barley straw	0	0	0	0
Corn Stover	0	0	0	0
Subtotal	307,929	2,418	2,533,685	223.27
Animal waste(Dry matter is VS)				
Dairy manure	0	0	0	0
Cattle manure	58,614	395	413,568	36.4
Swine manure	104	1.10	1,155	0.10
Poultry manure	0	0	0	0
Subtotal	58,718	396	414,723	36.500
Food packing				
Cull onions	73	0.62	654	0.058
Cull potatoes	0	0	0	0
Cull apples	0	0	0	0
Asparagus butts	24	0.17	173	0.015
Subtotal	97	0.79	827	0.073
Field processing				
Mint slug	0	0	0	0
Hops	0	0	0	0
Subtotal	0	0	0	0
Food processors				
Asparagus	8.72	0.058	61	0.0054
Apple pomace	528	3.66	3,839	0.34
Grape pomace	0	0	0	0
Berry pomace	0	0	0	0
Potato solids	60	0.78	816	0.072
Subtotal	596.7	4.498	4716	0.4174
Municipal Solid Wastes (MSW)				
Waste water treatment	1,302	10.3	10,827	0.95
Food waste	1,019	15.9	16,639	1.46
Yard debris				
Lawn clippings	376	2.22	2,325	0.20
Leaves	1,526	5.72	5,991	0.53
Other yard debris	572	2.41	2,528	0.22
Others				
Vegetable oils	16.8	0.50	521	0.046
Animal fats reclaimed	N/A	N/A	N/A	N/A
Glycol from airplane de-icing	59	1.73	1,811	0.16
Glycerol from biodiesel	N/A	N/A	N/A	N/A
Subtotal	4,871	38.8	40,642	3.57
TOTAL	372,212	2,858	2,994,593	264

County: Whitman	Biomass (dry)	Methane	Heat Value	Energy (1,000 M Wh)
Field residues	Tons/yr	M cu. ft	M Btu	at 30% Efficiency
Wheat straw	624,449	4,907	5,142,391	452
Bluegrass straw	2,850	13.1	13,758	1.21
Barley straw	1,595	12.4	12,982	1.14
Corn Stover	0	0	0	0
Subtotal	628,894	4,933	5,169,131	454.4
Animal waste(Dry matter is VS)				
Dairy manure	863	5.81	6,090	0.54
Cattle manure	19,568	132	138,064	12.1
Swine manure	1,829	19.3	20,274	1.78
Poultry manure	6.27	0.066	69.5	0.0061
Subtotal	22,266	157	164,498	14.43
Food packing				
Cull onions	0	0	0	0
Cull potatoes	0	0	0	0
Cull apples	0	0	0	0
Asparagus butts	0	0	0	0
Subtotal	0	0	0	0
Field processing				
Mint slug	0	0	0	0
Hops	0	0	0	0
Subtotal	0	0	0	0
Food processors				
Asparagus	0	0	0	0
Apple pomace	0.55	0.0038	3.97	0.00035
Grape pomace	0	0	0	0
Berry pomace	0	0	0	0
Potato solids	0	0	0	0
Subtotal	0.55	0.0038	3.97	0.00035
Municipal Solid Wastes (MSW)				
Waste water treatment	946	7.51	7,867	0.69
Food waste	734	11.4	11,992	1.05
Yard debris				
Lawn clippings	271	1.60	1,676	0.15
Leaves	1,099	4.12	4,315	0.38
Other yard debris	412	1.74	1,822	0.16
Others				
Vegetable oils	4.86	0.14	150	0.013
Animal fats reclaimed	N/A	N/A	N/A	N/A
Glycol from airplane de-icing	48	1.41	1,476	0.13
Glycerol from biodiesel	N/A	N/A	N/A	N/A
Subtotal	3,515	27.9	29,298	2.57
TOTAL	654,676	5,118	5,362,930	471

County: Yakima	Biomass (dry)	Methane	Heat Value	Energy (1,000 M Wh)
Field residues	Tons/yr	M cu. ft	M Btu	at 30% Efficiency
Wheat straw	47,127	370	388,095	34.1
Bluegrass straw	188	0.87	908	0.080
Barley straw	7,862	61	63,991	5.63
Corn Stover	20,427	212	222,369	19.6
Subtotal	75,604	644	675,363	59.4
Animal waste(Dry matter is VS)				
Dairy manure	207,078	1,394	1,461,096	128
Cattle manure	92,331	621	651,326	57.3
Swine manure	200	2.12	2,217	0.19
Poultry manure	2,627	27.8	29,131	2.56
Subtotal	302,236	2,045	2,143,770	188.1
Food packing				
Cull onions	67	0.57	599	0.053
Cull potatoes	0	0	0	0
Cull apples	0	0	0	0
Asparagus butts	133	0.93	976	0.086
Subtotal	200	1.50	1575	0.139
Field processing				
Mint slug	103	1.20	1,254	0.11
Hops	2,690	31.1	32,628	2.87
Subtotal	2793	32.30	33882	2.98
Food processors				
Asparagus	49	0.33	341	0.030
Apple pomace	4,666	32.4	33,959	2.99
Grape pomace	777	5.97	6,252	0.55
Berry pomace	0.060	0.00048	0.50	0.000044
Potato solids	7.03	0.091	96	0.0084
Subtotal	5499	38.8	40649	3.578
Municipal Solid Wastes (MSW)				
Waste water treatment	5,178	41.1	43,059	3.79
Food waste	4,054	63.2	66,195	5.82
Yard debris				
Lawn clippings	1,496	8.83	9,253	0.81
Leaves	6,070	22.7	23,830	2.10
Other yard debris	2,276	9.60	10,061	0.88
Others				
Vegetable oils	233	6.88	7,209	0.63
Animal fats reclaimed	N/A	N/A	N/A	N/A
Glycol from airplane de-icing	59	1.73	1,811	0.16
Glycerol from biodiesel	N/A	N/A	N/A	N/A
Subtotal	19,366	154.0	161,418	14.19
TOTAL	405,698	2,915	3,056,657	268

Key units of measurement and assumptions of statistical relevance were utilized in the production of the following tables and figures. Key units were: heat value of CH_4= 1,048 Btu/ft^3 CH_4; 1 kWh=3,412 Btu; 1 kWh=3.6 MJ; M=10^6; and 1 ton=2,000 lbs. Statistically, zero values, "0"; included in the tables do not refer to an absolute zero but a statistically insignificant amount.

Appendix A: Biomass Inventory Assumptions and References

The following outline and associated narrative describe the resources referenced and the necessary assumptions made for every biomass waste stream studied. Where appropriate, a section was added to certain biomass waste streams delineating any concerns and probable need for future research. Although some biomass streams have their own unique concerns, there were some general concerns that applied across the board when determining the data and producing the inventory. These concerns are summarized below:

(1) All of the numbers are at a county level, not beyond. The overarching approach to data collection was one of top down not bottom up. By this it is meant that, for the most part, state statistical data was divided into county data using per capita statistics as opposed to directly finding individual county data. It is important to mention this because this approach does introduce a higher degree of error primarily because it does not effectively take into account unique county variances. Additionally, awareness of this approach will help future researchers when the existing data is used for an even lower level (i.e. sub-county).

(2) What grew in the county, stayed in the county. That is the assumption made. For example, an apple grown in Walla Walla might have been transported to Yakima for processing and eventual release of its waste, however because of lack of information, this transportation and area-processing component was not addressed.

(3) Multiple uses of the wastes resulted in difficulties in tracking these materials. Many of the agricultural, commercial, and municipal waste streams such as wastewater treatment plant biosolids and composted yard waste are already being used in multiple ways and thus finding economic and environmental benefits for what once were un-valued by-products. This, though, made the tracking of the waste stream difficult on an inventory basis. For example, apples harvested in the field are culled producing a potential waste source, but in reality that source is utilized in apple processing to make apple sauce which has its own waste stream that in turn is utilized to make dehydrated apple chips which, of course, has its own waste stream that is potentially utilized as an additive to cattle feed. As mentioned in point number (2), this is a transport and tracking challenge, but, in addition, it is a statistical concern. For example, how to determine the eventual overall waste stream percentage, how to keep track of changes in moisture content and therefore dry weight, and lastly, how to keep track whether or not the waste is being fed to cattle and therefore already being tallied as manure? Unfortunately, in many cases the answer to these questions was not enough information or no information, which led to possible errors in the data.

(4) 100% utilization of the biomass was assumed. For example, when calculating the glycol waste from airplane de-icing, it was assumed that all of the tonnage used could theoretically be collected and processed for its energy. Of course this is not a reality and in fact only a small percentage of the glycol can be recovered.

Field Residue

Wheat Straw

1. *Wheat Straw for Ethanol Production in Washington: A Resource, Technical, and Economic Assessment* (September 2001, WSUCEEP2001084)
2. Washington Agricultural Statistical Service, *Agricultural Statistics* Washington 2001 Annual Bulletin (http://www.nass.usda.gov/wa/whtco03.pdf)
3. Donald L. Klass. 1998. *Biomass for Renewable Energy, Fuels, and Chemicals*, ISBN 0-12-410950-0, Academic Press, San Diego, CA, 1998.

Key Data and Assumptions

The amount of wheat production for 13 of the 20 counties was found by averaging the census data for 1996-2000 (2). The production of wheat straw was then calculated based on the production of wheat by using the equation: lbs of wheat straw per acre = 69.76 × yield (bushels/ acre) + 1067.7 (1). The overall objective of leaving a certain amount of wheat straw in the field is to ensure long-term soil fertility and erosion control. However, the amount of wheat straw left in the field was not in consensus (1), due to multiple affecting factors such as weather, crop rotation, existing soil fertility, the slope of the land, wind pattern, rainfall patterns and tillage practices. In the extensive study that quantified the amount of wheat straw available for collection, a number corresponding to 3,000 or 5, 000 lbs/acre was chosen as the amount of wheat straw that should be left on the field (1). In this project, we have used 4, 000 lbs/acre of wheat straw being left on the field. The production of wheat straw in the three counties (Asotin, Columbia, and Okanogan) was calculated by the same equation but used averaged production data for the years 2000 and 2001 (2). The amount of collectible wheat straw equals the amount of production minus 4, 000 lbs/acre. The data of the other four counties (Chelan, Ferry, Kittitas and Pend Oreille) are small enough to be negligible (2).

Grass Straw

1. Washington Agricultural Statistical Service, *Agricultural Statistics* www.nass.usda.gov/census/census97/volume1/wa-47/toc297.htm http://www.nass.usda.gov/wa/grassco03.pdf http://www.nass.usda.gov/wa/grass.pdf
2. *Status Report on Alternative Uses of Grass Straw* by the Department of Ecology (#99-208) Dec. 1999, (http://www.ecy.wa.gov/pubs/99208.pdf)

Key Data and Assumptions

Seed production numbers were arrived at by averaging the 1997-2002 state production totals and then applying that average to the county level by using the 1997 county percentage numbers (1). In doing so, it was assumed that, although total state production changed from year to year, the percentage of seed produced per county stayed relatively constant. By comparing seed production and straw harvest production for the year 1998, a ratio of straw to seed harvest was obtained

(1,2). That ratio was 4.28 lbs of straw harvested/pound of seed harvested. It was assumed that this ratio is relatively constant from year to year and county to county.

Concerns and Further Study
Presently, a certain percentage of the straw is being used to process particleboard while the remainder is being used as compost. No exact percentages were available for how much straw went to each use, so given that fact and the belief that, regardless of use, neither composting or particle-board production are utilizing the straw for their direct energy or power, we included all 100 percent of production as a possible unused energy.

Barley Straw

1. Washington Agricultural Statistical Service, *Agricultural Statistics* Washington Annual Bulletin (1999-2001) (http://www.nass.usda.gov/wa/barco03.pdf
2. Donald L. Klass. 1998. *Biomass for Renewable Energy, Fuels, and Chemicals*, ISBN 0-12-410950-0, Academic Press, San Diego, CA, 1998.

Key Data and Assumptions
The equation for calculating collectible barley is: tons/yr of collectible barley straw = yield (tons/yr) x residue factor (2.5) x available factor (0.60) x percent of dry weight (91%) (2). The barley yield was an average of years 1999-2001 (1).

Corn Stover

1. Washington Agricultural Statistical Service, *Agricultural Statistics* Washington Annual Bulletin (http://www.nass.usda.gov/wa/cornco03.pdf)
2. Donald L. Klass. 1998. *Biomass for Renewable Energy, Fuels, and Chemicals*, ISBN 0-12-410950-0, Academic Press, San Diego, CA, 1998.

Key Data and Assumptions
The production of corn stover was an average based on the data of corn yield for the years 1999-2001 (1). The equation for calculating collectible corn stover was: tons/yr of collectible corn stover = yield (tons/yr) x residue factor (1.10) x available factor (0.60) x percent of dry weight (53%) (2).

Animal Manure

The animal manure biomass data is a measurement of the amount of volatile solids (VS) and not the total pounds manure produced, since it is this VS amount that leads to the production of methane gas. The general approach for quantifying the VS in animal manure is based on the VS production rate/live weight of the various stock animals.

Dairy

1. *Dairy Database*, Washington Department of Ecology document
2. *Manure production and characteristics* in ASAE, D 384.1 DEC 99.

Key Data and Assumptions
Information on dairy, including the number of milkers, dry, heifers, and calves is from the database provided by WADOE (1). After assuming the average weight of all the animals, the amount of volatile solids (VS) was calculated based on the VS production rate/live weight (2). This rate assumed was: 10 kg VS produced/ 1,000 kg live cows/day (2). The assumed average weights were: milker = 640 kg, dry = 600 kg, heifer = 400 kg, and calve = 150 kg (2).

Cattle

1. Washington Agricultural Statistical Service, *Agricultural Statistics* Washington Annual Bulletin (1998-2002) (http://www.nass.usda.gov/wa/agri1may.pdf)
2. *Manure Production and Characteristics* in ASAE, D 384.1 DEC 99.

Key Data and Assumptions
The number of cattle is the number of all cattle and calves minus those of dairy. The number of all cattle and calves is the average of the five-year (1998-2002) data supplied by the Washington Annual Bulletin (1). After assuming the percentage of beef and veal, and their average weight, the VS production was calculated from the VS production rate/live weight (2). The assumed VS production rate was: 7.2 and 2.3 kg VS/1,000 kg live weight/day for beef and veal respectively (2). The assumed ratio of beef to veal was: 80% beef to 20% veal (estimated). The assumed average live weights of beef and veal were 360 kg and 91 kg respectively (2).

Swine

1. Washington Agricultural Statistical Service, *Agricultural Statistics* Washington Annual Bulletin (1997-2001) (http://www.nass.usda.gov/wa/agri1feb.pdf)
2. *Manure Production and Characteristics* in ASAE, D 384.1 DEC 99.

Key Data and Assumptions
The number of swine is the average of five years (1997-2001) (1). After assuming the average weight of swine, the VS production was calculated from the VS production rate/live weight (2). The assumed VS production rate was: 8.5 kg VS/1,000 kg live weight/day (2). The assumed average live weight of swine was 61 kg (2).

Poultry

1. National Agricultural Statistical Service-*1992 Agricultural Census (http://www.nass.usda.gov/census/census97/volume1/us-51/us1_19.pdf)*
2. *Manure Production and Characteristics* in ASAE, D 384.1 DEC 99.

Key Data and Assumptions
The number of poultry is from data taken during the 1992 agricultural county-by-county census (1). After assuming the average weight of layers, pullet, broilers, turkeys and ducks, the VS production was calculated from the VS production rate/live weight (2). The assumed VS production rate was: 12, 17, 9.1 and 19 kg VS/1,000 kg live weight/day for layer/pullet, broiler, turkey, and duck

accordingly (2). The average live weight of layer/pullet, broiler, turkey and duck were assumed to be 1.8, 0.9, 6.8 and 1.4 kg respectively (2). In turkey/others, we assumed 90% turkey to10% duck (estimate).

Food Packing

Cull Onions

1. National Agricultural Statistical Service-*1997 Agricultural Census* http://www.nass.usda.gov/wa/counties/vegrank.htm#ons
2. Interview with Sunspiced (http://www.sunspiced.com/wacontact.html)

Key Data and Assumptions

10% of total onion production is cull onions, and of this 10%, only 5% are plowed back into the ground, with the other 5% being processed as frozen product (2). Thus the final cull onion tally is represented by 5% of total county production that is not utilized (1).

Concerns and Future Study

We were not able to determine from Sunspiced what kind of waste stream is produced from the 5% that go to making frozen onions. There surely is some waste, but as of yet it is not known how much or where it goes.

Cull Potatoes

1. Washington Agricultural Statistical Service, *Agri-Fact February, 2003* http://www.nass.usda.gov/wa/agri2feb.pdf
2. National Agricultural Statistical Service-*1997 Agricultural Census* http://www.nass.usda.gov/wa/counties/fldrank.htm#pot
2. USDA North Dakota Agriculture Statistics Service*, 1997 Cull Potatoes* *http://www.nass.usda.gov/wi/vegetables/potato_sizegrade.pdf*
3. Conversation with Andy Jensen, Washington State Potato Commission (http://www.potatoes.com/)

Key Data and Assumptions

Crop yields were averaged from 2000-2001 total crop data and county percentage data (1,2). North Dakota Agriculture Statistical Service article pointed out that 15-19% of all potatoes are cull potatoes (3). Conversation with Potato Commission pointed out that 15% of all harvested potatoes go to the fresh market while the other 85% go to processing (4). Within the fresh market, they have 90% pack-out and 10% cull, with that 10% going to a dehydrator plant (4).

Thus, although there are "cull potatoes" in the sense that they are not good enough to make the fresh market, there really are no true cull potatoes in the sense that they are wasted. All of the poor quality potatoes go to some kind of processing, and therefore the amount of cull potatoes was assumed to be zero. The waste stream from that processing is addressed later.

Cull Apples

1. National Agricultural Statistical Service: 1997 Agriculture Census (http://www.nass.usda.gov/census/census97/volume1/wa-47/wa2_31.pdf)

2. Interview with Don Wiser of the Washington Tree Fruit Research Commission (http://www.treefruitresearch.com/)

Key Data and Assumptions
The interview pointed out that 23-27% of all harvested apples are cull apples, which are sent to processors. Thus, as with potatoes, all of the cull apples are utilized.

Concerns and Future Study
In discussions with experts, they all admit that there is a lot of wasted fruit on/near the trees, but in their knowledge that waste has never been tabulated.

Asp. Butts

1. Washington Agricultural Statistics Service: Agri-facts, Feb. 2003 (http://www.nass.usda.gov/wa/agri1feb.pdf)
2. National Agricultural Statistical Service: 1997 Agriculture Census (http://www.nass.usda.gov/wa/counties/vegrank.htm#asp)
3. Interview with Alan Schreiber at the Asparagus Commission (http://www.washingtonasparagus.com/)

Key Data and Assumptions
Crop yields were an average drawn from data years 99-01(1,2). The Asparagus Commission interview pointed out that processing requires the removal of 25% of the dry mass in the form of the asparagus butt (3). Presently, they say about 51% of waste butts are going to animal feed and the other 49% are going to compost (3). Inventory numbers, then, reflect only the 49% of asparagus butts that are not going to cattle feed. The cattle feed numbers were not counted because they eventually end up being counted in the cattle manure.

Field Processing

Mint Slug

1. National Agricultural Statistical Service-*1997 Agricultural Census* http://www.nass.usda.gov/wa/counties/fldrank.htm#pep
2. Interview with FarWest Spearmint (http://www.farwestspearmint.org/quality.htm)

Key Data and Assumptions
FarWest Spearmint supplied information that for 1 acre of crop approximately 7.5 tons of mint is produced and from that only 120 pounds of oil is distilled (2). Thus 99.3 % of mint is left as waste. 95% of this is returned to fields while 5% is used to control road dust to/from distillery (2). Final mint slug numbers then were a result of multiplying 99.3% by the county mint production (1, 2).

Concerns and Further Study
Given the non-energy use of the slug, 100% of all the waste was included in the energy values. Since this slug is flash steamed, its composition is going to be altered and possibly affect the production of energy via anaerobic digestion. In

addition, it was hard to determine the percentage of moisture content after the distillation.

Hops

1. Washington Agricultural Statistics Service, *Hops Data Sheet*, (http://www.nass.usda.gov/wa/annual02/hops02.pdf).
2. Interview with USA Hops (http://www.usahops.org/english/index.asp)

Key Data and Assumptions
County hop yields were an average drawn from data years 97-01 (1). Information supplied by USA Hops pointed out that 50% of green weight harvest is waste and 100% of the waste is returned to the field or composted (2). Final hops numbers then were a result of multiplying the average county harvest by 50% (1,2).

Food Processing

Asparagus

1. Interview with Alan Schreiber at the Asparagus Commission (http://www.washingtonasparagus.com/)
2. Interview with Phil Klaus at Seneca Foods (http://www.senecafoods.com/)

Key Data and Assumptions
Conversations with Allen Schreiber and Phil Klaus point out that all asparagus is de-butted, but 60% of that de-butted crop goes to processing for canning and there is an additional 10% loss, which goes completely to field supplement (1, 2). Thus, this item in the inventory was a value represented by 10% of 60% of the de-butted asparagus crop.

Concerns and Future Study
This 60% goes to 3 separate canneries in Walla Walla, Columbia, and Yakima counties, but percentages to each is proprietary knowledge, thus we did NOT move the values to the cannery location, but instead kept them in the originating fields even though technically they are now in different counties.

Apple Pomace

1. Interview with Processing Manager at Treetop (www.treetop.com)
2. Processed Apple Institute web page (www.appleproducts.org)
3. Interview with Welcome Sauer at Washington Best Apples (welcomes@bestapples.com)

Key Data and Assumptions
Treetop interview showed that 10% of all processed apples end up as waste. In year 2000, 39% of apples were processed while 59% directly shipped and 2% were not marketed (2). Of the processed 39%, 23% was juice/cider, 2% dried, 2% frozen, 11% canned, and 1% miscellaneous (2). Conversation with Washington Best Apples put the amount processed at 30-34% instead of the 39% quoted by Apple Institute (3). Regardless of exactly what the processing product was, this value was simply represented by 10% of the 32% (Best Apples average) processing of the overall annual crop (1, 3).

Concerns and Future Study

The type of product produced in the processing really does matter. Although the 10% value quoted by Treetop is a best guess for the overall average of all the different types of processing, a more accurate value will only be arrived at if one knows the type of waste stream produced by each type of processing. More importantly for this data is the fact that neither Treetop, nor anyone else, was able to give us an accurate idea of how the eventually processed waste was dealt with, i.e. if some of the waste was given as animal feed. As discussed before, this is very important; in order to ensure that there is not a duplicating of data/energy with the manure values.

Grape Pomace

1. National Agricultural Statistical Service USDA: 1997 Agriculture Census (http://www.nass.usda.gov/wa/counties/orchrank.htm#grap)
2. Washington Agricultural Statistical Service, Washington Grape Report, January 2003 (http://www.nass.usda.gov/wa/grape03.pdf)
3. University of California at Davis SAREP article, *The Promise of Pomace*, by Chuck Ingels, Fall 1992 (http://www.sarep.ucdavis.edu/NEWSLTR/v5n1/sa-3.htm).
4. Washington Agricultural Statistical Service article, *News October 2002* (http://www.nass.usda.gov/wa/appgrape.pdf)
5. Economic Research Service-USDA article, Fruit and Tree Nut Outlook, January 2003 (FTS-302) (http://www.ers.usda.gov/Briefing/FruitAndTreeNuts/fruitnutpdf/highlightFresh.pdf).

Key Data and Assumptions

Crop yields were from the 1997 census, 1997 county percentage data, and the Washington Grape Report (1, 2). For every 1-ton of grapes there are 20-100 pounds of stems and 160-240 pounds of pomace (3). This is used for feed, compost and/or burned (3). 34% of Washington grapes harvested are for wine production while the other 64% go to grape juice or marketed grapes (4). Calculating from UC-Davis stats, 9.1% of wine-grape becomes pomace and including stems, 11.8% of wine-grape harvest is waste (3). 13.2% of grapes are fresh sold, thus in Washington State 86.8 % of grapes are processed (5). We assumed that grape juice production has about the same waste pomace as wine. Thus, this item in the inventory is a value represented by 9.1% waste pomace of the 86.8% processing material of the harvested grape crop.

Concerns and Future Study

It was noted that some of the pomace was used for cattle feed, but we were not able to get a percentage on this, thus it could not be taken into consideration. Also, the moisture content of the pomace is bound to be different depending upon the type of processing, so the determined energy values could presumably be affected by this variance. Lastly, the stem waste was not considered in the calculation although it does have energy value.

Berry Pomace

1. National Agricultural Statistical Service USDA: *1997 Agricultural Census* (http://www.nass.usda.gov/census/census97/volume1/wa-47/wa2_31.pdf)
2. Oregon Agricultural Statistical Service USDA: *Berry Production January* 2001 (http://www.nass.usda.gov/or/berry01.pdf)
3. Economic Research Service-USDA article, Fruit and Tree Nut Outlook, January 2003 (FTS-302) (http://www.ers.usda.gov/Briefing/FruitAndTreeNuts/fruitnutpdf/highlightFresh.pdf).

Key Data and Assumptions

Crop yields were an average calculated from 1997 county percentage data and further berry data from the year 2000 (1,2). 2000 data pointed out that berry production in Washington State has increased by 32% between the years 1997 and 2000 (2). Assuming that the percentage's per county stayed approximately the same we multiplied the 1997 county numbers by 1.32 to get a more accurate 2000 county report (1,2). Using 2000 crop percentage data and fresh market percentages in a weighted average, it was found that 35.2% of berry production mass was processed in the State of Washington (3). With an assumption of 9.1% waste production as with grapes, the berry pomace value then was represented by 9.1% of the 35.2% of the updated county berry harvest.

Concerns and Future Study

Concerns are similar to that of grapes: (1) does the type of processing affect the composition of the waste, (2) does the type of processing affect the moisture content of the waste, and therefore the calculated energy values, and (3) what happened to the waste, and in particular, has any of it gone to animal feed?

Potato Solids

1. Washington Agricultural Statistical Service, *Agri-Fact February, 2003* http://www.nass.usda.gov/wa/agri2feb.pdf
2. National Agricultural Statistical Service-*1997 Agricultural Census* http://www.nass.usda.gov/wa/counties/fldrank.htm#pot
3. Conversation with Andy Jensen, Washington State Potato Commission (http://www.potatoes.com/)

Key Data and Assumptions

Crop yields were averaged from 2000-2001 total crop data and county percentage data (1,2). 85% of all Washington potatoes go to processing (3). An average 10% waste stream generated throughout the potato processing process was assumed. This assumption was not from any data made available from the potato industry, but from the 10% that was quoted from the apple processing industry. This may be an inaccurate assumption, but no direct data could be found. Thus the potato solid waste stream was determined by taking 10% of 85% processing of the total average county harvest.

Concerns and Future Study
The greatest concern was the lack of a processing waste percentage. Additionally disturbing is the lack of information in regards to use of the waste stream as cattle feed. It is known that potatoes are extensively used as cattle feed, but no data could be found on the percentage.

Municipal Solid Waste

Biosolids

1. EPA document (EPA 530-R-99-009), September 1999, *Biosolids Generation, Use, and Disposal in the United States* (http://www.epa.gov/epaoswer/non-hw/compost/biosolid.pdf).
2. *Biomass for Renewable Energy, Fuels, and Chemicals* by Donald L. Klass, Academic Press, 1998.
3. Personal interview with Larry Bennett of Montgomery Watson Harza *(208-345-5865)*
4. Email correspondence with Kyle P. Dorsey [KDOR461@ECY.WA.GOV]
5. *County Population Statistics for 2000* from Washington State Office of Financial Management, County Population Projections (http://www.ofm.wa.gov/pop/gma/index.htm).

Key Data and Assumptions
People produce, on average, 0.2 lbs sludge/person/day or 73 lbs/person/year with 64% reduction rate after digestion, making, on average, 47 lbs dry biosolid/person/year (3). This statistic was converted from per person to per county using county census projections (5). 2003 population numbers were found by averaging the 2000 data with the 2005 projection (5). Additionally, in year 2000, 63% of biosolids produced were used for beneficial uses like, composting and soil-supplement, while 37% were used for no soil amendment or energy value (1). However, although this 63% was of greater beneficial use it was not directly used for its energy, thus we assumed that all of the tallied mass was unutilized energy.

Concerns and Further Study
We assumed all biosolids were of consistent composition even though biosolids are generated through a variety of systems, which ultimately produce biosolids with different composition. The assumption is acknowledged to be problematic, as it is known that some biosolids are already anaerobically digested and that some biosolids are of low energy value. Individual wastewater assessment is needed to accurately estimate biogas yield.

Food Waste

1. *Municipal Solid Waste in the United States: 2000 (EPA 530-R-02-001) June 2002,* (http://www.epa.gov/epaoswer/non-hw/muncpl/report-00/report-00.pdf).
2. *County Population Statistics for 2000* from Washington State Office of Financial Management, County Population Projections (http://www.ofm.wa.gov/pop/gma/index.htm).

Key Data and Assumptions

In 2000, US yard and food waste recovery was 0.32 pounds/day/person (1). 56.9% of yard trimmings were recovered and 2.6% of food was recovered (1). Additionally, 48.3% of yard/food waste was food waste (1). Given that data, calculations with the following simultaneous equations:

$$0.569x + 0.026y = 0.32$$
$$0.483(x + y) = y$$

show that 0.504 pounds/day/person is food waste and 0.539 pounds/day/person is yard waste. Using the county population statistics and multiplying by 365 days/year a pounds/year/county value was obtained (2).

Concerns and Further Study

These statistical numbers reflect food and yard waste that is produced by each person regardless of whether they dispose of it in a landfill or in their backyard. Thus, by including all amounts produced, it is being assumed that all of the waste could in the future be used to generate power. Statewide solid waste reports and some county by county solid waste sorting data has been reported that would be very applicable and extremely useful in future assessment of food waste and the other solid waste types that follow.

Grass

1. *Municipal Solid Waste in the United States: 2000 (EPA 530-R-02-001) June 2002,* (http://www.epa.gov/epaoswer/non-hw/muncpl/report-00/report-00.pdf).
2. *Feedstock Composition at Composting Sites* by Cary Oshins and Dave Block in BioCycle, September 2000, p. 31. (http://www.jgpress.com/BCArticles/2000/090031.html)
3. *County Population Statistics for 2000* from Washington State Office of Financial Management, County Population Projections (http://www.ofm.wa.gov/pop/gma/index.htm).

Key Data and Assumptions

Calculations were achieved given the above, derived data about yard waste (0.539 lbs/day/person) and the fact that the yard waste is composed of 30% grass, 30% brush, and 40% leaves (2). Thus grass production comes out to be 59.02 lbs/year/person when multiplied by the 30% grass production rate and 365 days/year. County level numbers were achieved using the quoted population statistics (3).

Concerns and Further Study

Writers of the BioCycle article point out that calculating an average yard waste composition is difficult at best. Their data show that the individual numbers fluctuate widely depending on time, season, and region. Thus, although this is a national average based on considerable data points, it might not reflect the averages for Washington State or a particular county in Washington.

Brush

1. *Municipal Solid Waste in the United States: 2000 (EPA 530-R-02-001) June 2002,* (http://www.epa.gov/epaoswer/non-hw/muncpl/report-00/report-00.pdf).
2. *Feedstock Composition at Composting Sites* by Cary Oshins and Dave Block in BioCycle, September 2000, p. 31. (http://www.jgpress.com/BCArticles/2000/090031.html)
3. *County Population Statistics for 2000* from Washington State Office of Financial Management, County Population Projections (http://www.ofm.wa.gov/pop/gma/index.htm).

Key Data and Assumptions
Exactly the same assumptions and calculations as for grass.

Leaves

1. *Municipal Solid Waste in the United States: 2000 (EPA 530-R-02-001) June 2002,* (http://www.epa.gov/epaoswer/non-hw/muncpl/report-00/report-00.pdf).
2. *Feedstock Composition at Composting Sites* by Cary Oshins and Dave Block in BioCycle, September 2000, p. 31. (http://www.jgpress.com/BCArticles/2000/090031.html)
3. *County Population Statistics for 2000* from Washington State Office of Financial Management, County Population Projections (http://www.ofm.wa.gov/pop/gma/index.htm).

Key Data and Assumptions
Exactly the same assumptions and calculations as for grass and brush with the exception of the use of the 40% leaf production ratio (2).

Oils

1. Washington State Department of Ecology, *Oil Recycling by County for Years 1997-1999* (#00-07-037)
2. National Renderers Association web page at http://www.renderers.org/Environment/index.htm

Key Data and Assumptions
EPA now lists vegetable oil, animal fat, and all other oils like motor oil as oil when discussing recycling and waste management. Department of Ecology data was an average of the years 97-99 and appears to be just a listing of recycled motor oil (1). Rendering plants produced 9 billion lbs of processed animal/vegetable oil in year 2000 for the whole country. All of this was converted to animal feed supplements, thus was not included in data (2). There still are no bio-diesel plants in Washington State, thus there appear to be no concerted efforts to recycle the commercial quantities of vegetable and animal oils.

Concerns and Further Study
There is considerable data in regards to motor oil production but very little data on vegetable and animal oil/fat production or recycling. Thus, additional research

will be needed to determine the amount of commercial vegetable and animal oil production and where the waste streams or recycling efforts are eventually ending up. Also, the county oil data was data about recycled oil coming into landfills and collection sites but does not take into account the amount of oil that is not being disposed of properly and is being wasted as an energy source.

Glycol

1. Phone interview with Maintenance and Supply Division of Southwest Airlines (www.southwest.com).
2. Weather and flight information at Pullman Regional Airport (http://www.ci.pullman.wa.us/airportfacts.htm)
3. Flight information and personal interview at Spokane International Airport (http://www.spokaneairports.net/pass_data.htm)
4. Personal interview with Public Affairs Department at Fairchild Air Force Base (https://www.fairchild.af.mil/).
5. Weather and airport flight information at Airnav (http://www.airnav.com/airport/KPSC).

Key Data and Assumptions

Runway maintenance at Spokane International Airport pointed out that all runway de-icing at most airports is done through the use of urea while all airplane de-icing is done using glycol-based chemicals. Individual airlines control and keep track of the amount of de-icing that occurs (3). On average 150 gallons of antifreeze is used to de-ice a commercial jet, but that number can skyrocket to as high as 2,000 gallons if weather and icing problems are at their worst (1). In addition to de-icing, airlines use approximately 35 gallons of glycol to anti-ice a commercial jet (1). A variety of glycol-based antifreezes are utilized by the airlines including ethylene glycol, propylene glycol and mixtures like Type 4 (1).

Weather information from Pullman Regional Airport and Airnav point out that Eastern Washington experiences, on average, 15.8 days of inclement flying weather per month during the 4-month winter period (November-February) of which 50% of these are potential de-icing days (2,5).

Number of flights information was obtained for all Eastern Washington regional airports. These commercial/military flight numbers are: Pullman (4 flights departing/day), Spokane (216 departing flights/day, Fairchild (6 sortie departures/day), Walla-Walla (5 flights departing/day), Tri-Cities (8 flights departing/day), Grant County Regional (54 flights departing/day), and Yakima (5 flights departing/day) (2,3,4,5). A 50/50 ratio of glycol to antifreeze was assumed and the density of glycol is 9.28 lbs/gallon. Calculation equation then is:

(9.28 lbs/gallon G)(0.5 ratio G/AF)(185 gallons AF/flight)(#flights/day)(31.6 de-icing days/year)

Concerns and Further Study

A rather round about way of calculating county-wide glycol use at airports was required because individual airlines, with the exception of Southwest, were unwilling to release the information. In addition, the calculation is based on ratios

that have considerable potential error. Examples of this are: (1) the gallons of antifreeze used is quite varied depending on the severity of the storm, (2) these numbers are only for commercial jets of average size and any differences based on size were not tabulated, (3) only commercial and military flight departures were measured and these were only averages per day, (4) different glycol solutions were used which affect the assumed ratios and densities, and last (5) the average de-icing days in a given year is quite varied and depends upon the micro-climates at the airport. Also, these calculated numbers point out the total number of pounds of glycol used in each county, but do not take into account the difficulty of collecting the glycol. Lastly, no data was included in regards to recycled or used antifreeze from ground-based vehicles.

Glycerol 1. Email from Washington Department of Ecology

Key Data and Assumptions

The Department of Ecology pointed out that still at this time there are no bio-diesel processing plants in operation within the state of Washington (1). With this information, it was assumed that there is no large commercial production of glycerol in the state of Washington or in any of its counties.

Appendix B: Energy Inventory Assumptions and References

The general procedure to calculate the bioenergy in the above-tallied biomass was to: (1) calculate the dry biomass by adjusting the raw biomass with respect to their moisture content, (2) calculate the amount of volatile solids (VS) using the dry biomass data and VS content, (3) calculate the production of methane using the VS data and methane yield/unit VS, and (4) calculate the production of energy using the methane data and typical conversion efficiencies from methane to energy.

The following information outlines the necessary assumptions and corresponding references used when following the above described four-step process for energy calculation from the inventoried biomass. Within each step described is a short paragraph describing the general approach made and a table displaying the important assumption and reference information.

Step 1: Converting Raw Biomass Data to Dry Biomass

The moisture content in a variety of raw biomass was used to calculate the amount of dry biomass, as the content of VS is based on the dry weight of biomass for most biomass. The detailed information is listed in Table 1.

Table 1. Moisture Contents in Different Raw Biomass

Biomass Category	Values	Basis or Reference
Wheat straw	There was no need to adjust by moisture content, as the raw biomass for these four field residues was directly inventoried as dry weight.	
Bluegrass straw		
Barley straw		
Corn Stover		
Dairy manure	The moisture content in the four types of animal manure was not taken into account, since the bioenergy in manure is calculated from the methane generated by anaerobic digestion of the VS in manure, and the VS in animal manure is directly calculated from animal types and weight (ASAE, D384.1 DEC99).	
Cattle manure		
Swine manure		
Poultry manure		
Cull onions	90%	Moisture contents from USDA National Nutrient Database for Standard Reference, Oct. 2002. http://www.nal.usda.gov/fnic/foodcomp/Data/SR15/reports/sr15page.htm
Cull potatoes	81%	
Asparagus butts	92%	
Asparagus peel	92%	
Apple pomace	84%	
Grape pomace	92%	
Berry pomace	92%	
Potato solids	81%	
Mint slug	85%	Estimated
Hops	73%	Moisture content from USA Hops webpage, *Drying and Baling*, http://www.usahops.org/english/farm_dry.asp
Waste water treatment *	*biosolids from waste water treatment are already measured as dry biomass, so no moisture is needed in the relevant calculation.	

Food waste	80%**	75% for Inedible plant biomass.	http://www.ees.ufl.edu/escstc/reports/ar2003-web/ar2002-03g-app-02.htm#03g-t02
		80 ~ 90% moisture content for fresh food waste.	http://216.239.33.100/search?q=cache:rImgw3WZHcsJ:www.ces.uga.edu/pubcd/B1189.htm+food+waste+%22moisture%22&hl=en&ie=UTF-8
		** estimated based on the above information.	
Lawn clippings	77%	Moisture content from *Cornell Composting-Science and Engineering* by Nancy Trautmann and Tom Richard, http://www.cfe.cornell.edu/compost/calc/moisture_content.html	
Leaves	30%	Moisture content from *Horticulture Facts-Leaf Disposal* by David Williams, Department of Natural Resources and Environmental Services (NRES-18), http://web.aces.uiuc.edu/vista/pdf_pubs/LEAFDISP.PDF	
Other yard debris (Misc.)	65%		
Vegetable oils	10%	Estimated based on the typical moisture range of grain and seeds.	
Glycol from airplane de-icing	10%	Estimated	

Step 2: Calculating Content of Volatile Solids (VS) in Various Dry Biomass

Volatile solids (VS) is the most prevalent index of methane production in anaerobic digestion, and the production of methane is often expressed as per unit VS. VS content is typically expressed as the percentage of total solid (TS). Table 2 below gives VS content values for the dry biomass studied. Note how much the VS values can vary by type of biomass.

Table 2. VS Contents of Biomass Used in the Project

Categories of Biomass	Values Used	Values in Literature	References
Wheat straw	86% TS	Organic is 86%	Klass, 1998 (P. 150).
Bluegrass straw	89.8% TS	89.8% TS. 86.5% of weight.	Wiley & Sons, 1985 (P.1269). Meyers, 1983 (P.722).
Barley straw	85% TS	85% is organic.	Klass. 1998 (P.150).
Corn Stover	90% TS	90% is organic.	Klass. 1998 (P.150).
Dairy manure	The VS in animal manure is directly calculated (ASAE, D384.1 DEC99).		
Cattle manure			
Swine manure			
Poultry manure			
Cull onions	95% TS	> 95% of TS). *	Gunaseelan, 1997 (P. 91)*
Cull potatoes	95% TS	> 95% of TS). *	Gunaseelan, 1997 (P. 91)*
Cull apples	95% TS	> 95% of TS). *	Gunaseelan, 1997 (P. 91)*
Asparagus butts	95% TS	> 95% of TS). *	Gunaseelan, 1997 (P. 91)*
Mint slug	95% TS	> 95% of TS). *	Gunaseelan, 1997 (P. 91)*
Hops	95% TS	> 95% of TS). *	Gunaseelan, 1997 (P. 91)*
Asparagus	95% TS	> 95% of TS). *	Gunaseelan, 1997 (P. 91)*
Apple pomace	95% TS	> 95% of TS). *	Gunaseelan, 1997 (P. 91)*
Grape pomace	95% TS	> 95% of TS). *	Gunaseelan, 1997 (P. 91)*

Berry pomace	95% TS	> 95% of TS). *	Gunaseelan, 1997 (P. 91)*
Potato solids	95% TS	> 95% of TS). *	Gunaseelan, 1997 (P. 91)*
Wastewater treatment	75% TS	73.47% of weight (Primary sewage sludge). 73.5% of TS (Primary sewage sludge). 76.5% of TS (Primary-activated sewage sludge	Meyers, 1983 (P.722) (1) Wiley & Sons, 1985 (P.1269) (2). Wiley & Sons, 1985 (P. 1269).
Food waste	90% TS	90~94% of TS. 92% of TS.	** ***
Lawn clippings	88.1% TS	88.1% of TS (grass)	Owens and Chynoweth, 1993.
Leaves	95% TS	88.1% of TS (leaves)	Owens and Chynoweth, 1993.
Other yard debris (Misc.)	92% TS	92% of TS (blend)	Owens and Chynoweth, 1993.
Vegetable oils	98% TS	Estimated based on its composition and high methane generation capacity.	
Glycolfrom airplane de-icing	98% TS	Estimated based on its similarity with vegetable oils.	

Step 3: Calculating Methane Yield from the VS Content of Biomass

Methane yield from biomass is expressed as the amount of methane produced per VS unit. The data in Table 3 shows that methane yield differs greatly for different biomass.

Table 3. Methane Yield from Different Biomass (m^3/kg VS)

Categories of Biomass	Values Used in the Project (m^3/kg VS)	Values in Literature (m^3/kg VS)	References or Notes
Wheat straw	0.285	0.162~0.383 with average = 0.285 of 21 data.	Tong et al., 1990. Steward et al., 1984. Sharma et al., 1988. Badger et al., 1979. Hashimoto, 1986. Ashimoto, 1987.
Bluegrass straw	0.16	0.16	Wiley & Sons, 1985 (P.1269).
		0.15	Meyers, 1983 (P. 728).
Barley straw	0.285	Estimated based on its high similarity with wheat straw.	
Corn Stover	0.36	0.36	Tong et al., 1990.
Dairy manure	0.21*	0.156 (complete mix) and 0.187 (plug flow)-mesophilic.	Wiley & Sons, 1985 (P.1271).
		0.33 (12d) and 0.22 (4d)-thermophilic.	Wiley & Sons, 1985 (P.1274).
		0.195 (mesophilic, 20d) and 0.190 (thermophilic, 12d)	Wiley & Sons, 1985 (P.1275).
		0.21~0.23 for large scale, 0.22 ~ 0.24 for laboratory scale.	Elsevier Science Inc. 1995 (P. 1222-1233).

		0.2 m^3 methane (0.33 m^3 biogas) from the manure for high roughage diets	Bioenergy '96 (p. 503)
		*Used the average of the values in the cited references.	
Cattle manure	0.21	Used the same value as dairy manure.	
Swine manure	0.33**	0.17 m^3	Bioenergy '96 (P.91)
		0.33 m^3 from the manure for high grain diets.	Bioenergy '96 (P. 503).
		0.497 (from 0.35/kg COD and 1 kg VS = 1.42 kg COD)-hog manure.	Bioenergy '96 (P. 1024-1025)
		** Used the average (mean) of the three values.	
Poultry manure	0.33	0.33 m^3 from the manure for high grain diets.	Bioenergy '96 (P. 503)
Cull onions	0.28	Estimated by comparing various values of fruit wastes.	
Cull potatoes	0.426	0.426	Steward et al., 1984.
Cull apples	0.228	0.228 (data of apple waste)	Lane, 1984.
Asparagus butts	0.23	0.23 (data of asparagus waste)	Lane, 1984.
Mint slug	0.38	0.38 (data of fruit and vegetable wastes)	Viturtia et al., 1989.
Hops	0.38		
Asparagus	0.219	0.219 (value of asparagus peel)	Knol, et al., 1978.
Apple pomace	0.228	0.228 (data of apple waste)	Lane, 1984.
Grape pomace	0.252	Average of 6 values of fruit wastes.	Viswanath et al., 1992.
Berry pomace	0.261	0.261 (data of strawberry-slurry).	Knol, et al., 1978.
Potato solids	0.426	0.426	Steward et al., 1984.
Waste water treatment	0.33	0.31 (Primary sewage sludge)	Meyers, 1983 (P. 728).
		0.33 (Primary sewage sludge)	Wiley & Sons, 1985 (P.1269)
		0.34 (Primary-activated sewage sludge)	Wiley & Sons, 1985 (P.1269)
		0.313 (primary solids)	Klass, 1998 (P. 474)
		0.327 (primary activated biosolids)	Klass, 1998 (P. 474)
Food waste	0.54	http://www.ees.ufl.edu/escstc/reports/ar2003-web/ar2002-03g-app-02.htm#03g-t02	
Lawn clippings	0.209	0.209 (data of grass from yard waste samples)	Owens and Chynoweth, 1993.
Leaves	0.123	0.123	Owens and Chynoweth, 1993.
Otheryard debris (Misc.)	0.143	0.143 (blend from yard waste samples)	Owens and Chynoweth, 1993.
Vegetable oils	0.94	http://www.ees.ufl.edu/escstc/reports/ar2003-web/ar2002-03g-app-02.htm#03g-t02	
Glycolfrom airplanede-icing	0.94	Estimated based on its similarity with vegetable oils in terms of easily biodegradable and the value of vegetable oils.	

Step 4: Efficiency from Methane to Power

The efficiency from biomass to power can largely be divided into three levels: low efficiency (about 20%), medium efficiency (about 30%), and high efficiency (about 40%), even though the conversion efficiency from various biomass to power is strongly dependent on the scale of power plants and the types of electric generators. The efficiencies listed in Table 4 are from sources involving case studies or laboratory scale experiments. The chosen project efficiency ratio of 30% for the computer program is approximately the average or median efficiency level, and it is also a reachable level under current available technology.

Table 4. Efficiency from Biomass to Energy (Electricity)

Efficiency (%)	Scale	Types of Generators	References
24.3%	10-50 MW	Condensing power systems	John Wiley & Sons, Inc. 1985. (P. 1261).
24.2%	35 MW	Boiler	John Wiley & Sons, Inc. 1985. (P. 1264).
20%-24%	10 MW	Not specified	Elsevier Science Inc., 1995 (P. 89).
25% to 35%, typically 30%	Depending on the scale (1 – 10) MW		Elsevier Science Inc., 1995 (P. 1020).
6%	Small	Steam engine	Elsevier Science Inc., 1995 (P. 1037).
21.5%		Conventional steam plant	Elsevier Science Inc., 1995 (P. 342-350).
43%		Combined cycle gas turbine steam plant	
28.4%	Small to medium scale	Conventional steam	Klass, 1993 (P. 149).
38 %	Reachable or target efficiency		Klass, 1993 (P. 149).
24.4%	Efficiency from biogas to power		Klass, 1993 (P. 1091).
24.7%	Stand-alone boiler/steam turbine		Klass, 1993 (P. 1133).
31.7%	Efficiency of highly efficient boiler		Klass, 1993 (P. 1133)
31%,	Efficiency of steam injected gas turbine		Klass, 1993 (P. 1134)
38.3%,	Efficiency of intercooled steam injected gas turbine		Klass, 1993 (P. 1134)
38%	150 MW	Advanced systems	Klass, 1993 (P. 1140)
20.4%	30 MW	California	Klass, 1993 (P. 1149)
24.7%	> 50 MW		
31.7%	>50 MW, reheat system		
32%	51 MW		
38.3%	114 MW		
35-40%	Medium	Gas turbine combined cycle	Bioenergy ’96 (P. 44)
20-25%	Medium	Conventional	Bioenergy ’96 (P. 44)
24.4%	Conventional anaerobic using swine manure		Bioenergy ’96 (P. 91)
23%	5 MW	Gas turbine	Bioenergy ’96 (P. 393)
23%	Efficiency from biogas to power		Bioenergy ’96 (P. 1036)
25%	Efficiency from methane to power		Bioenergy ’96 (P. 1050)
34-39%	Efficiency from fossil fuel (coal) to power		Bioenergy ’96 (P. 183)
25-35%	Efficiency from landfill/sewage biogas to power		James & James Science Publishers Ltd, 1996.
35-50%	Efficiency of combined cycle generators		
22%	Efficiency of electricity production in MSW comb		James & James (P. 52).

Sample Calculation

Example of calculation from the volatile solids (VS) of dairy manure

- **Step 1: VS production rate:**
  A 1,000 kg cow produces 10 kg VS/day (This VS is already dry weight).
  Therefore, a 1,000 kg cow produces 3650 kg VS/yr.
  Or, a 1 kg cow produces 3.*65 kg VS/yr*.
- **Step 2: VS production from dairy weight**
  VS produced in a dairy farm/year (kg VS/yr) = 3.65 (kg VS/1kg yr) × total weight(kg), with the assumption of the average weights being: milker = 640 kg, dry = 600 kg, heifer = 400 kg, and calve = 150 kg.
  Total weight (kg) = ∑ number of each type × its average weight.
  Thus, for a dairy farm with the numbers of milkers = 117, dry = 10, heifers = 90, and calves = 15;
  The VS for the whole farm/yr = 3.65 kg VS/1kg×yr (117 × 640+10 × 600 + 90 × 400 + 15 × 150) kg = *434,825 kg VS/yr*.
- **Step3: VS to methane**
  The production rate of methane from VS is 0.21m^3 CH_4/kg VS (standard condition: 20 ^oC and 1 atmospheric pressure).
  Thus, the amount of methane produced/yr = 0.21m^3 CH_4/kg VS × 434,825 kg VS/yr = 91, 313 m^3 CH_4/yr = *3,224,262 ft^3 CH_4/yr*.
- **Step 4: Methane to potential energy**
  The potential energy (M Btu/yr) = 3,224,262 ft^3 CH_4/yr × 1,048 Btu/ft^3 ÷ 10^6 = *3,379 M Btu/yr*. (* 1,048 Btu /ft^3 CH_4 is the heat value of pure dry CH_4). * M = 10^6.
- **Step 5: Potential energy to electrical energy**
  The energy in terms of electricity = 3,379 M Btu/yr ÷ 3,412 Btu/kW.h × 30% (efficiency from potential energy to electricity) = 0.30 M (kW.h)=3 x 10^6 kW h.

Appendix C: List of Washington State Food Processors

Below is a list of Washington State Food Processors and Research Resources requested by the Department of Ecology. The list was compiled through internet search, email/phone conversations, and referencing the *Directory of the Canning, Freezing, Preserving Industries 2002-2003* by E. E. Judge.

Washington State Food Processors

Agrilink Foods, Inc. — **Various Canned Vegetables**
3303 S. 35th St., PO Box 11046
Tacoma, WA 98411
253-383-1621
253-272-2730

American Nutrition, Inc. — **Pet Food**
350 N. Pekin Rd., PO Box 810
Woodland, WA 98674
360-225-8855
360-225-8855

Basic American Foods — **Dehydrated Potatoes**
538 Potato Frontage Rd
Moses Lake, WA 98837
509-765-8601
509-766-3207

Basin Frozen Foods — **Frozen Potatoes**
12-3 Basin PO Box 747
Warden, WA 98857
509-349-2210
509-349-2375

Bybee Fresh Cut — **Frozen Onions**
1801 Commercial Ave.
Pasco, WA 99301
509-547-5109
509-543-9748

Chiquita Processed Foods, LLC — **Various Canned Vegetables**
516 Rose St., PO Box 458
Walla Walla, WA 99362
509-525-8390
509-529-1416

Chukar Cherries — **Cherry Products**
320 Wine County Rd.
Prosser, WA 99350
509-786-2055

Columbia Foods, Inc. — **Various Frozen Vegetables**
12329 Old Snohomish Monroe Rd., PO Box 249
Snohomish, WA 98291-0249
509-787-1585
509-787-1735

PO Box 605
Quincy, WA 98848

Del Monte Foods — **Various Canned Fruits & Vegetables**
108 W. Walnut St., PO Box 1528
Yakima, WA 98907
509-865-4105
509-865-2226

49 East 3rd Ave.
Toppenish, WA 98948
509-575-6580
509-575-8771

Enfield Farms, Inc. — **Various Frozen Berries**
1064 Birch Bay-Lynden Rd.
Lynden, WA 98264
360-354-3019
360-354-0503

Firestone Packing Co., Inc. — **Various Frozen Berries**
4211 N.W. Fruit Valley Rd., PO Box 61928
Vancouver, WA 98666
360-695-9484
360-695-0040

Foster Farms — **Frozen Chicken**
1700 S. 13th Ave.
Kelso, WA 98626
360-575-4900
360-575-4948

Graysmarsh Farm, Inc. — **Various Frozen Berries**
6187 Woodcock Rd.
Sequim, WA 98382
360-683-5563
360-683-6509

Green Garden Food Products, Inc. — **Variety of Canned Veg/Meat**
5851 S. 194th St.
Kent, WA 98032
253-395-4460
253-395-0408

Independent Food Processors Co. — **Variety Fruit Juices**
PO Box 1588
Yakima WA 98907
509-457-6487
509-457-7983

1525 S. 4th St.
Sunnyside, WA 98944

Isernio's Sausage Co., Inc. — **Variety Meat Sausages**
5600 7th Ave. S.
Seattle, WA 98108
206-762-6307
206-762-5259

Jewel Apple Ltd. — **Canned Apples**
601 N. First Ave. PO Box 27
Yakima, WA 98907
509-248-7200
509-453-3835

Johnson Concentrates, Inc. — **Variety Juice/Purees**
310 E. Edison Ave. PO Box 955
Sunnyside, WA 98944
509-837-4600
509-837-5151

Johnson Fruit Co., Inc. — **Variety Frozen/Pickled Fruit**
336 Blaine Ave., PO Box 916
Sunnyside, WA 98944
509-837-4214
509-837-4855

300 Warehouse Ave.
Sunnyside, WA 98944
509-839-3243
509-837-4188

Jones Produce Dehydrates — **Dehydrated Potato**
903 A Street, PO Box 487
Quincy, WA 98848-0487
509-787-3537
509-787-5418

Lamb-Weston, Inc. — **Variety of Potato Products**
PO Box 1900
Tri-Cities, WA 99302
509-787-3567
509-787-9220

1005 E. St. SW, PO Box 368
Quincy, WA 98848
509-547-8851
509-545-8203

811 W. Gum St. PO Box 799
Connell, WA 99326
509-234-5511
509-234-5515

2013 Saint St.
Richland, WA 99352
509-375-4181
509-375-5808

960 Glade Rd. North, PO Box 2324
Pasco, WA 99301

McCain Foods, USA, Inc. — **Frozen Potatoes**
100 Lee St., PO Box 607
Othello, WA 99344
509-488-9611
509-488-3942

MEMBA — **Variety Frozen Berries**
729 Loomis Trail Road
Lynden, WA 98264
360-354-4504

816 Loomis Trail Road
Lynden, WA 98264
360-354-2094
360-354-3906

Mike and Jean's Berry Farm **Variety Frozen Berries**
16402 Jungquist Rd.
Mount Vernon, WA 98273
360-424-7220
360-424-7225

Milne Fruit Products, Inc. **Variety Fruit Juices**
804 bennett Ave., PO Box 111
Prosser, WA 99350
509-786-2611
509-786-1724

National Frozen Foods, Corp. **Variety Frozen Vegetables**
1600 Fairview Ave. E. Ste. 200, PO Box 9366
Seattle, WA 98109

436 NW State Ave.
Chehalis, WA 98532
360-748-4403

PO Box A
Moses Lake, WA 98837
509-766-0793

Naumes Concentrates, Inc. **Apple Juice**
3907-10 Chelan Hwy., PO Box 3920
Wenatchee, WA 98807
509-662-2222
509-662-3021

Noel Corp. **Variety Fruit Juices**
1001 S. First St.
Yakima, WA 98901
509-248-4545

1011 S. Third St.
Yakima, WA 98901
509-575-1729

The Northern Group — **Dehydrated Veg/Fruit Juices**
1420 5th Ave., Ste 3670
Seattle, WA 98101
206-622-0771
206-622-3319

Northwest Tart Cherry Inc. — **Cherry Products**
5170 N. Wahluke Rd.
Basin City, WA 99343
509-269-4100
509-269-4949

Oberto Sausage Co. — **Mixed Meat Sausages**
7060 S. 238th St. PO Box 429
Kent, WA 98305
253-437-6100

2005 Airport Way S.
Seattle, WA 98134
206-264-5841

1715 Rainier Ave. So.
Seattle, WA 98114
206-264-5841

Ocean Spray Cranberries Inc. — **Cranberry Products**
1480 State Route 105
Aberdeen, WA 98520
360-648-2354
360-648-2201

Ochoa Ag Unlimited, Inc. — **Variety Potato/Vegetable Products**
255 South Lind-Hatton Road
Lind, WA 99341-9746
509-677-3358
509-667-3328

Olympic Foods, Inc. — **Variety Meat Products**
5625 W. Thorpe Rd.
Spokane, WA 99224
765-452-4008
765-452-4086

Washington Potato Co. — **Dehydrated Potatoes**
1900 W. 1st Ave., PO Box 2248
Warden, WA 98857-1048
509-349-8803
509-349-2362

Pacific Blueberries, Inc. — **Blueberry Products**
17440 Moon Rd. SW
Rochester, WA 98579
360-273-5405
360-273-5425

Phranil Foods — **Frozen Fruit Pies**
3900 E. Main
Spokane, WA 99202
509-534-7770
509-534-4244

Rader Farms, Inc. — **Variety Berry Products**
1270 E. Badger Rd.
Lynden, WA 98264
360-354-6574
360-354-7070

Robinson Cold Storage — **Variety Berry Products**
24415 NE 10th Ave.
Ridgefield, WA 98642
360-887-3501
360-887-4271

Safeway Inc. — **Fruit/Vegetable Juices**
201 N. Euclid
Grandview, WA 98930
509-882-1105
509-882-3043

Sakuma Bros. Processing Inc. — **Variety Berry Products**
17400 Cook Rd., PO Box 426
Burlington, WA 98233
360-757-3822
360-757-3835

Seneca Foods Corp., Vegetable Division — **Apple/Potato Chips and Canned Veg.**
711 E. Main St.
Dayton, WA 99328-1443
509-457-1089
509-457-8959

2418 River Rd.
Yakima, WA 98902
509-382-2511
509-382-3182

Shonan Inc. — **Fruit and Vegetable Juices**
702 Wallace Way, PO Box 128
Grandview, WA 98930
509-882-5583
509-882-5898

JR Simplot Co.-Food Group — **Variety Potato and Vegetable Products**
14124 Wheeler Rd. NE
Moses Lake, WA 98837
509-765-3413
509-766-2160

1201 North Broadway
Othello, WA 99344
509-787-452
509-787-3926

222 Columbia Way, PO Box 817
Quincy, WA 98848
509-544-6700
509-544-6799

5815 Industrial Way, PO Box 3199
Pasco, WA 99302
509-488-2671

JM Smucker Co. — **Berry Pressing/Jams/Juices**
100 Forsel Rd. PO Box 608
Grandview, WA 98930
509-882-1530
509-882-2212

Snokist Growers — **Variety Apple/Fruit Products**
18 W. Mead PO Box 1587
Yakima, WA 98907-1587
509-453-5631
509-457-6417

2506 Terrace Hts, Rd.
Yakima, WA 98901

Stockpot, Inc. — **Meat/Vegetable Soups**
22505 State Rt. #9
Woodinville, WA 98072-6010
425-415-2000
425-415-2006

SVZ-USA, Inc. — **Variety Fruit/Vegetable Products**
1500 N. Briadway, PO Box 715
Othello, WA 99344
509-488-6563
509-488-2631

Symons Frozen Foods, Inc. — **Frozen Vegetables**
619 Goodrich Rd.
Centralia, WA 98531
360-736-1321
360-736-6328

PJ Taggares Co. — **Grape Products**
850 N. Broadway
Othello, WA 99344
509-488-3356
509-488-5198

Tree Top, Inc. — **Variety Apple Products**
220 E. Second Ave., PO Box 248
Selah, WA 98942-0248
509-663-8583
509—663-7190

PO Box 1300
Wenatchee, WA 98807
509-782-2312
509-782-1896

PO Box O
Cashmere, WA 98815
509-697-0430
509-697-0477

205 S. Railroad Ave., PO Box 248
Selah, WA 98942
509-697-0432
509-697-0417

101 S. Railroad Ave.
Selah, WA 98942
509-786-2926
509-786-4128

2780 Lee Rd.
Prosser, WA 99350

Twin Cities Food, Inc. **Variety Vegetable and Potato Products**
10120 269th Place NW, PO Box 699
Stanwood, WA 98292
360-629-2111
360-629-3533

PO Box 478
Ellensburg, WA 98926
509-962-9806
509-962-1991

PO Box 1040
Prosser, WA 99350
509-546-0850
509-547-4776

PO Box 1326
Pasco, WA 99301
509-786-2700
509-786-4247

Uni-Heartous Pet Products USA, Inc. **Pet Food**
144 N. Canal St.
Seattle, WA 98103
206-632-7500
206-632-4458

Valley Processing , Inc — **Variety Apple/Berry Products**
108 E. Blaine, PO Box 246
Sunnyside, WA 98944
509-837-8084
509-837-3481

Washington Frontier Juice — **Various Fruit Juices**
660 Frontier Road
Prosser, WA 99350

Washington Tart Cherry Products, Inc. — **Cherry Products**
3408 SE Road 10.5
Othello, WA 99344
509-965-5953
509-965-8650

Watts Brothers Frozen Foods, LLC — **Variety Vegetable Products**
187107 S. Watts Rd., PO Box 278
Paterson, WA 99345
509-875-2423
509-875-2323

Wax Orchards, Inc. — **Variety Fruit Products**
22744 Wax Orchards Rd. SW
Vashon Island, WA 98070
206-463-9735
206-463-9731

Welch Foods, Inc. — **Variety Grape Products**
10 E. Bruneau St.
Kennewick, WA 99336
509-882-3112

504 Birch St.
Grandview, WA 98930
509-582-213509-582-1702

Wineries — **Wine Products**
For a list of all wineries go to
The following web page:
http://www.washingtonwine.org/wwc/default.cfm?action=wineries&page=3

Appendix D: Research Resources

A. Washington Agricultural Commissions

Washington Agricultural Commodity Commissions

Alfalfa Seed Commission *	**Cranberry Commission ***	**Puget Sound Salmon Commission ***
Ken Maurer, Executive Director P.O. Box 2945 Pasco, WA 99302 Phone: 509/547-5538 Fax: 509/547-5563	Glen Thompson, Chair P. O. Box 597 Grayland, WA 98547 Phone : 360-532-4527 Fax : 360-532-4527	David Harsila 1900 W Nickerson St, #116, PMB 210 Seattle, WA 98119 Phone: 206/595-8734 Fax: 206-542-3930
Apple Commission RCW 15.24	**Dairy Products Commission** RCW 15.44	**Red Raspberry Commission ***
Welcome Sauer, President P.O. Box 18 Wenatchee, WA 98807 Phone: 509/663-9600 Fax: 509/662-5824	Steve Matzen, General Manager 4201 198th St SW #101 Lynnwood, WA 98036 Phone: 425/672-0687 Fax: 425/672-0674	Henry Bierlink, Executive Director 1796 Front St. Lynden, WA 98264-1260 Phone: (360) 354-8767 Fax: (360) 354-0948
Asparagus Commission *	**Dry Pea &Lentil Commission ***	**Seed Potato Commission +**
Alan Schreiber, Administrator PO Box 3817 Pasco, WA 99302 Phone: 509-266-4303 FAX: 509/266-4317	Tim McGreevy, Administrator 2780 W. Pullman Rd. Moscow, ID 83843 Phone: 208/882-3023 Fax: 208/882-6406	Doris Roosma, Secretary P.O. Box 286 Lynden, WA 98264 Phone: 360/354-4670 Fax: 360/354-4670
Barley Commission+	**Fruit Commission** RCW 15.28	**Strawberry Commission ***
Mary Palmer-Sullivan, Director W 905 Riverside #501 Spokane, WA 99201 Phone: 509/456-4400 FAX: 509/456-2807	B.J. Thurlby, President 105 S 18th Street #205 Yakima, WA 98901-2149 Phone: 509/453-4837 Fax: 509/453-4880	Norval Johanson, Manager 4430 John Luhr Road Olympia, WA 98516 Phone: 360/491-6567 Fax: 360/491-6567
Beef Commission RCW 16.67	**Fryer Commission +**	**Tree Fruit Research** RCW 15.26
Patti Brumbach, Executive Director 14240 Interurban Avenue S. #224 Seattle, WA 98168 Phone: 206/444-2902 Fax: 206/444-2910	Sue Broderick, Office Manager 2003 Maple Valley Highway #212 Renton, WA 98055 Phone: 425/226-6125 Fax: 425/226-8238	Jim McFerson, Manager 1719 Springwater Ave Wenatchee, WA 98801 Phone: 509/665-8271 Fax: 509/663-5827
Blueberry Commission *	**Hop Commission ***	**Turfgrass Seed Commission ***
Dorothy Anderson, Secy./Treasurer 15903 Bow Hill Road Bow, WA 98232 Phone 360//766-6150 Fax: 360/766-4001	Ann George, Administrator PO Box 1207 Moxee, WA 98936 Phone: 509/453-4749 Fax: 509/457-8561	Vacant, Administrator P.O. Box 2022 Pasco, WA 99302 Phone: 509/547-5538 Fax: 509/547-5563
Bulb Commission +	**Mint Commission ***	**Wheat Commission +**
Mike Shelby, Manager 2017 Continental Pl .#6 Mt. Vernon, WA 98273 Phone: 360/424-7327 Fax: 360/424-9343	Rod Christensen, Executive Director 100 North Fruitland, Suite B Kennewick, WA 99336 Phone: 509/585-5460 FAX: 509/585-2671	Tom Mick, CEO W. 907 Riverside Avenue Spokane, WA 99201-1006 Phone: 509/456-2481 Fax: 509/456-2812
Canola Commission *	**Potato Commission +**	**Wine Commission** RCW 15.88
Joe Alvarnez, Administrator P.O. Box 4381 Pasco, WA 99302 Phone: 509/547-5538 Fax: 509/547-5563	Pat Boss, Executive Director 108 Interlake Road Moses Lake, WA 98837 Phone: 509/765-8845 Fax: 509/765-4853	Steve Burns, Executive Director 93 Pike Street, Ste. 315 Seattle, WA 98101 Phone: 206/667-9463 Fax: 206/583-0573

*from the Washington State Department of Agriculture, Commodity Commissions Program (http://agr.wa.gov/Links/CommodityCommissionList.pdf)

B. Agricultural Statistical Services

National Agricultural Statistics Service
http://www.usda.gov/nass/

Washington Agricultural Statistics Service
http://www.nass.usda.gov/wa/homepage.htm

C. Miscellaneous

Northwest Food Processors Association
http://www.nwfpa.org/

Washington State Agricultural Agencies

OrganizationName	Address	City	WA	PostalCode
Dairy Federation	717 Gish Rd.	Onacaska	WA	98570-
Farm Bureau	13501 Union Flat Creek Rd.	Endicott	WA	99125-
Farm Bureau	PO Box 2009	Olympia	WA	98507-
Hop Growers of WA	1045 Desmarais Rd.	Moxee	WA	98936-
Hop Growers of WA	7820 Ashu E. Rd.	Wapato	WA	98951-
Hop Growers of WA	504 N Naches Ave Ste 11	Yakima	WA	98901
Hop Growers of WA	504 N. Naches Ave. #11	Yakima	WA	98901-
Kittitas Hay Growers	3591 Tjossem Road	Ellensburg	WA	98926-
NW Bulb Growers Assn.	17297 Hulbert Rd.	Mount Vernon	WA	98273
NW Bulb Growers Assn.	PO Box 303	Mt. Vernon	WA	98273-
NW Hay Cubers Assn.	2012 W Yelsley Rd	Othello	WA	99344
NW Nursery Imp. Inst.	Po Box 458	Quincy	WA	98848-
OR-WA Pea Growers Assn.	1345 Bryant Ave	Walla Walla	WA	99362
Pacific NW Christmas Tree Growers Assn	17717 Pendleton St. SW	Rochester	WA	98579-
PNW Oilseeds Assn.	1551 N Dewald	Ritzville	WA	99169
PNW Vegetable Assn.	PO Box 3141	Pasco	WA	99302
Potato Growers of WA	PO Box 563	Othello	WA	993340563
Puget Sound Christmas Tree Assn.	202 16th Ave.	Seattle	WA	98122-5613
Puget Sound Seed Growers Assn.	2017 Continental Pl Ste 6	Mount Vernon	WA	982735649
River Irrigation Assn.	913 Surrey Truce SE	Tumwater	WA	98501-
WA Assn. of Conservation Districts	PO Box 60055	Shoreline	WA	98160-
WA Assn. of Wheat Growers	109 East First Avenue	Ritzville	WA	99169
WA Assn. Of Wheat Growers	262 Conover Rd.	Waitsburg	WA	99361-
WA Assn. Of Wheat Growers	6431 54th Ave. NW	Olympia	WA	98502-
WA Assn. of Wine Grape Growers	PO Box 2003	Pasco	WA	99302
WA Blueberry Growers Assn.	2462 Zell Rd.	Ferndale	WA	98248-
WA Cattleman's Assn.	PO Box 96	Ellensburg	WA	98926-
WA Cattleman's Assn.	PO Box 96	Ellensburg	WA	98926-
WA Cattlemen's Assn.	PO Box 96	Ellensburg	WA	98926
WA Cranberry Alliance	PO Box 903	Ilwaco	WA	98624-
WA Cranberry Alliance	2592 State Route 105	Grayland	WA	98547
WA Dry Pea & Lentil Comm.	2780 W. Pullman Rd.	Moscow	WA	83843-4024
WA Fish Growers Assn.	10420 173rd Ave SW	Rochester	WA	98579
WA Fish Growers Assn.	PO Box 5	Pateros	WA	98846-
WA Friends of Farm and Forests	PO Box 7644	Olympia	WA	98507-
WA Fryer Comm.	2003 Maple Valley Hwy, Ste 212	Renton	WA	98055-3925

WA Growers Clearing House	PO Box 477	Entiat	WA	98822-
Wa Growers Clearing House	6787 Flowery Divide	Cashmere	WA	98815-
WA Growers Clearing House Assn.	P O Box 2207	Wenatchee	WA	98807-2207
WA Mint Growers Assn.	10542 Division South Rd.	Othello	WA	99344-
WA Poultry Industries Assn.	40400 Harts Lake Valley Rd	Roy	WA	98580
WA Red Rasberry Comm.	1323 Lincoln St. #204	Bellingham	WA	98226-
WA Rubarb Growers Assn.	PO Box 887	Sumner	WA	98390-
WA ST Beekeepers Assn.	5417 99th Ave NW	Gig Harbor	WA	98335-
WA ST Farm Bureau	PO Box 2009	Olympia	WA	98507
WA ST Grange	PO Box 1186	Olympia	WA	98507-
WA ST Horticultural Assn.	PO Box 136	Wenatchee	WA	98807-
WA ST Nursery & Landscape Assn.	PO Box 670	Sumner	WA	98390-0670
WA ST Pork Producers	Rt 1 Box 148	Farmington	WA	99128
WA ST Potato Commission	6290 Lane Rd.	Toppenish	WA	98948-
WA ST Potato Commission	2522 N. Proctor, PMB7	Tacoma	WA	98406-
WA ST. Dairy Federation	PO Box 8549	Lacey	WA	98509-8549
WA Turfgrass Seed Comm.	PO Box 2022	Pasco	WA	99302-
WA Wine Growers Assn.	123 Pisces Drive	Pasco	WA	99301
WA Wool Growers Assn.	Box 652	Washtucna	WA	99371
Walla Walla Sw. Onion Growers Assn.	Rt 2 Box 252	Walla Walla	WA	99362
Washington State Grange	PO Box 1186	Olympia	WA	98507-1186
Western WA Farm Crops Assn.	15510 Snee-Oosh Rd.	LaConner	WA	98257-
Western WA Farms Crops Assn.	2017 Continental Place Ste 6	Mt. Vernon	WA	98273-
WSHA	PO Box 10303	Yakima	WA	98909-
WSU Coop. Ext. Kittitas Co.	207 W. Tacoma	Ellensburg	WA	98926-
Yakima Growers-Shippers Assn.	110 River Ranch Lane	Dayton	WA	99328-
Yakima Growers-shippers Assn.	PO Box 1688	Yakima	WA	98907-
Yakima Valley Grower-Shippers Assn.	PO Box 1688	Yakima	WA	98907-

**from Washington Secretary of State
(http://www.secstate.wa.gov/itrade/agricultural_orgs.aspx)

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