CO-FIRING WOOD IN COAL-FIRED INDUSTRIAL STOKER BOILERS:

Strategies for Increasing Co-Firing in New York and the Northeast

A Briefing Prepared for the:

Northeast Regional Biomass Program
Washington, D.C.

and the

New York State Energy Research and Development Authority
Albany, New York

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April, 1999

TABLE OF CONTENTS

	Page
SECTION 1: INTRODUCTION	**1**
The Purpose of this Project and Briefing	2
The Task Force on Biomass Co-Firing at Industrial Facilities	2
The Definition of Co-Firing	2
The Focus of Industrial Stoker-Fired Boilers	3
SECTION 2: COAL-FIRED INDUSTRIAL BOILERS IN NEW YORK STATE	**6**
SECTION 3: THE PERSPECTIVES OF TECHNICAL EXPERTS FAMILIAR WITH INDUSTRIAL BOILERS	**13**
Stoker Boiler Type	13
Stoker Boiler Steam Flow and Heat Input	13
Fuel Characteristics	13
Ash Deposition	14
Air Regulations	14
Boiler Planning	15
Boiler Maintenance and Operator Experience	15
Heating and Process Steam Demands	15
Cost of Natural Gas	16
The Availability of Natural Gas	16
The Availability of Biomass Fuel	17
SECTION 4: THE PERSPECTIVES OF MANAGERS/OPERATORS OF COAL-FIRED INDUSTRIAL BOILERS IN NEW YORK	**18**
Conversion to Natural Gas or Oil rather than to Co-Fire Biomass	19
Boiler Maintenance, Operation, and Planning	19
Industrial Interest in Co-Firing	20
Industrial Interest in Co-firing Technical Assistance Programs	20
SECTION 5: STRATEGIES TO INCREASE BIOMASS CO-FIRING IN INDUSTRIAL BOILERS IN THE NORTHEAST	**21**
Increase Awareness of and Commitment to Co-Firing in Non-Utility Boilers	21
Research and Identify Candidate Industrial Boilers	22
Publish and Distribute a Written Briefing on Co-Firing for Industrial Representatives	23

Provide Ready-Made Co-Fire Fuels to Industrial Boilers in the Northeast 23

SECTION 6: SUGGESTED NEXT STEPS FOR NYSERDA 26
Participate in Regional Efforts to Provide Ready-Made Co-Fire Fuel to Non-Utility Boilers 26
Explore Co-Fire Opportunities with NYSERDA's Energy Efficiency Services 26
Help Fund an Industrial Co-Fire Demonstration Project 27
Co-Sponsor and/or Host a Stoker Efficiency Network Workshop in New York 27

APPENDIX A: THE TASK FORCE ON BIOMASS CO-FIRING AT INDUSTRIAL FACILITIES A-1

APPENDIX B: NYSDEC SOURCE MANAGEMENT SYSTEM QUERY REPORTS FOR SOLID FUEL BOILERS WITH HEAT INPUTS OF 50,000 MMBTU/HR OR GREATER B-1

SECTION 1:

INTRODUCTION

Co-firing refers to supplementing coal use in coal-fired boilers with non-coal fuels. A basic premise of co-firing is that significant changes to the boiler(s) are not required beyond burner modifications or additions necessary to introduce and burn the supplemental fuel(s), and that the boiler is not significantly "derated" in terms of steam production. To meet these objectives, co-firing biomass fuels is typically done on a limited basis, with the amount of biomass used ranging from 5-15% of the total heat input to the boiler. Biomass fuels that have been successfully co-fired include wood and pelletized waste paper.

Co-firing should not be confused with the use of multiple fuels in boilers designed to burn multiple fuels. Multiple fuel boilers, such as those commonly installed and used as "power boilers" at pulp mills, are designed to burn a wide range of fuels such as coal, fuel oil, natural gas, whole tree chips, mill residues, bark, and paper sludge. The difference between a multiple fuel boiler and co-firing is that co-firing is done in a boiler originally designed to burn only (or primarily) a specific type of coal.

Nationwide and in certain portions of the Northeast region, interest is growing among electric utilities and others in co-firing biomass in coal-fired power plants. This is largely due to the need to improve air emissions from coal-burning facilities as well as to diversify fuel supplies. In New York, for example, two utilities already have direct experience co-firing biomass and coal. New York State Electric and Gas (NYSEG) co-fired biomass and coal at three power plants in the recent past, and continues to co-fire on a commercial basis at the Greenidge Station today. Niagara Mohawk is modifying its Dunkirk Station to facilitate co-firing biomass, which should be completed in 1999. Niagara Mohawk may co-fire at additional plants in the future. Co-firing has been successfully demonstrated at three large power plants in Pennsylvania, as well.

Despite the success with co-firing biomass and coal at utility power plants, co-firing is rarely practiced at industrial, institutional, and other non-utility coal-fired boilers. Although these boilers tend to be smaller than utility-scale boilers, they may be more numerous and have a geographic distribution that results in significant opportunities for co-firing. Similar to utility boilers, co-firing at non-utility boilers can:

- Reduce SOx emissions. Since woodfuel contains only trace amounts of sulfur, co-firing reduces SOx emissions by an amount which is proportional to the co-firing rate.

- Reduce emissions of the greenhouse gas CO2 and help address global warming. Since wood is considered by many to be "CO2 neutral," co-firing woodfuels also reduces CO2 emissions by an amount proportional to the co-firing rate. When woodfuels are grown on a long-term sustainable basis, the amount of CO2 emitted during combustion is equivalent to that absorbed during growth. This is very different than coal, which is considered to contribute CO2 on a long-term basis since the geological process from which coal is produced takes place over millions of years.

- Create markets for locally-grown, indigenous, and renewable fuels.
- Diversify the types of fuel used and the companies used to supply fuel.
- Provide additional markets for fuel suppliers.
- Help industries and other facilities meet or exceed goals for environmental stewardship.

The Purpose of This Project and Briefing

This briefing summarizes results of a study sponsored by the Northeast Regional Biomass Program (NRBP) and the New York State Energy Research and Development Authority (NYSERDA). The study was sponsored as part of the NRBP's ongoing efforts to stimulate biomass energy production and use in the Northeast region and NYSERDA's role in facilitating biomass energy use in New York State specifically. The purpose of the study was to identify strategies for stimulating biomass co-firing at non-utility coal-fired boilers. This briefing identifies industrial boilers in New York State permitted to burn coal, summarizes key factors affecting co-firing at industrial coal boilers, and suggests next steps the NRBP and NYSERDA could take to help increase co-firing in industrial stoker-fired boilers in the region overall and in New York State specifically.

The Task Force on Biomass Co-Firing at Industrial Facilities

A Task Force on Biomass Co-Firing at Industrial Facilities was formed as part of this project to provide a historical perspective on co-firing at coal-fired industrial boilers, identify key factors affecting co-firing at industrial stoker boilers, and help identify industrial boilers with high potential for co-firing. The Task Force consisted of over 20 industrial boiler experts including engineering consultants, boiler designers, boiler manufacturers, air emissions regulators, and biomass fuel suppliers. A list of the Task Force members is presented in Appendix A.

The Definition of Co-firing

In general, the term "co-firing" refers to use of a supplemental fuel in a boiler in addition to the primary fuel the boiler was originally designed to use. In this briefing, co-firing specifically refers to the supplemental use of woodfuels in addition to coal in stoker-fired boilers.

The Focus on Industrial Stoker-Fired Boilers

As noted above, the focus of this study is co-firing at non-utility (or "industrial") boilers. This includes boilers at industrial locations, institutions (such as state hospitals), universities (both state and private universities), and other non-utility facilities. For purposes of this study, these non-utility boilers are collectively referred to as "industrial boilers" (although they may actually be located at an institution or university).

It is technically feasible to co-fire woodfuels in a variety of coal-fired boilers, including underfeed, stoker, pulverized coal, and cyclone boilers. Research conducted for this study indicated the majority of coal-fired industrial boilers in the Northeast and New York State are stoker units and input provided by the Task Force indicated that stoker units are under increasing pressure to either be shut down or converted to natural gas. Based on the number of coal-fired stoker units as well as the lost opportunity for co-firing if coal-fired stoker units are shut down or converted to natural gas, the project team decided to focus this study on the potential for co-firing in stoker units.

SECTION 2:

COAL-FIRED INDUSTRIAL BOILERS IN NEW YORK STATE

Existing, non-utility boilers permitted to use coal in New York State were identified for this study, in order to assist NYSERDA in determining the extent of coal use by industries, institution, and other non-utility facilities in the state. Coal-fired industrial boilers were identified by performing a query of the New York State Department of Environmental Conservation's (NYSDEC's) Source Management System (SMS) database. The query was for solid fuel boilers in the state with heat inputs greater than 50 MMBtu/hr. The 50 MMBtu/hr criteria was used so that smaller hand-fired or underfeed units would not be included in results from the query. Results were obtained in a "report" for each of the 9 NYSDEC regions throughout the state. No solid fuel boilers were identified in Region 1 (which encompasses Long Island) with a heat input of 50 MMBtu/hr or greater, and thus a report was not generated for that region. Reports generated for the other eight regions are presented in Appendix B.

Presented in Tables 1 through 7 are summaries of coal-fired industrial boilers in Regions 2, 3, 4, 6, 7, 8, and 9. A table for Region 5 is not included since no coal-fired boilers are located in the region (although other types of solid fuel boilers are). The tables present key information about each facility and combustion unit(s) at each facility obtained from the query reports.

As shown in the tables, the SMS database indicates there are a total of 27 industries in New York State with a combined heat input of 50 MMBtu/hr or greater permitted to use coal. Within the 27 industries, there are a total of 80 boilers permitted to use coal. The 80 boilers include only those permitted to use coal. They do not include additional boilers located at the industries that are permitted to use fuels other than coal (such as wood, oil, or natural gas). Some of the facilities or boilers permitted to use coal may no longer use it, or the boilers may have been shut down since information was provided for the database. As part of this study, a sample of the 27 facilities were contacted and telephone interviews were completed with energy management or boiler operation staff. The interviews determined that at least two facilities (Middletown Psychiatric Center and The Gleason Works) have switched to natural gas and no longer use coal. It is well known that the Rome Air Force Base has closed, and thus it is likely the four coal-fired boilers at the base are idle. In addition, Delphi in Region 7 could not be reached, suggesting either the facility is closed or has been sold to another entity. Adjusting the database to account for these changes, the number of facilities using coal is estimated by the project team to be 23, and the number of boilers permitted to use coal at the facilities is estimated to be 70. However, not all facilities were contacted and it is likely other facilities have stopped using coal (due to switching to another fuel or shutting down) and thus, the actual number of facilities and coal-fired boilers in use at the facilities could be less.

As noted in the tables, the majority of industrial boilers are stoker-fired units, but several pulverized coal, cyclone, and fluidized bed units also exist.

The database contains data on "yearly fuel use," which is believed to represent the amount of coal used in each boiler on an annual basis. Based on yearly coal use reported in the database, an estimated 2.4 million tons of coal per year are used in industrial boilers in New York State. This estimate excludes the three facilities which no longer use coal (i.e. Middletown Psychiatric Center, Gleason Works, and the Rome Air Force Base), and excludes coal use at one boiler in Region 7 which is believed to be an error (CU Central Heating Plant, Emission Pt. 1, Combustion Unit C). This estimate correlates well with data presented in 1997 New York State Energy Fast Facts published by NYSERDA which notes that a total of 14,820,000 tons of coal were consumed in the state, and that industrial use accounts for 16% of the total. Based on this, it is estimated that industrial use of coal in New York State was about 2,371,200 tons in 1997.

In addition, yearly coal use data contained in the SMS database correlates well with information reported by energy managers and boiler operators at industries interviewed for this study. Four of the industries interviewed currently use coal and provided information on the amount of coal used annually. In three cases, information on coal use provided by energy managers or boiler operators was within ± 15% of that reported in the SMS database. In the fourth case, information provided during the interview was more than 50% lower than that reported in the database.

TABLE 1: NYSDEC SMS ANALYSIS FOR REGION 2 (For Non-utility Boilers Permitted to Use Coal)

Fac. Name, Address, Contact Person	Emission Pt	Combustion Unit	Type	Manufacturer	Heat Input (MMBtu/hr)	Burner	Fuel	Fuel Quantity (Lb/year)	Total Heat Input (MMBtu/hr)	Total Coal Quantity Tons/yr)
CHARLES EVANS HUGHES HS	10	A	1 Package Boiler	KEWANEE BOILER MODEL HFD 450	18.83	17 HAND-FIRED	1 ANTHRACITE COAL	500640		
351 WEST 18TH STREET		B	1 Package Boiler	KEWANEE BOILER MODEL HFD 450	18.83	17 HAND-FIRED	1 ANTHRACITE COAL	500640		
NEW YORK		C	1 Package Boiler	KEWANEE BOILER MODEL HFD 450	18.83	17 HAND-FIRED	1 ANTHRACITE COAL	500640	56.49	750.96
ANGELO DALESSIO										
								Region 2 Totals	56.49	750.96

TABLE 2: NYSDEC SMS ANALYSIS FOR REGION 3 (for Non-utility Boilers Permitted to Use Coal)

Fac. Name, Address, Contact Person	Emission Pt	Combustion Unit	Type	Manufacturer	Heat Input (MMBtu/hr)	Burner	Fuel	Fuel Quantity (Lb/year)	Total Heat Input (MMBtu/hr)	Total Coal Quantity (Tons/yr)
WASSAIC DEVELOPMENTAL CENTER	1	A	2 Built Up Boiler	HEINE TYPE V #400	58.6	DETROIT VIBRAGRATE STOKER	4 BITUMINOUS COAL	3036000		
ROUTE 22		B	2 Built Up Boiler	HEINE TYPE V #400	58.6	DETROIT VIBRAGATE STOKER	4 BITUMINOUS COAL	3036000	117.2	3036
WASSAIC										
DWAYNE KISHBAUGH										
HARLEM VALLEY PSYCHIATRIC CENT	1	A	99 Other	WICKS BOILER CO 58048	34.8	15 STOKER NEC	4 BITUMINOUS COAL	6057000		
ROUTE 22		B	99 Other	WICKS BOILER CO 58048	34.8	15 STOKER NEC	4 BITUMINOUS COAL	6057000		
WINGDALE		C	99 Other	WICKS BOILER CO 58048	34.8	15 STOKER NEC	4 BITUMINOUS COAL	6952000		
DS LEWIS		D	99 Other	WICKS BOILER CO 58048	34.8	15 STOKER NEC	4 BITUMINOUS COAL	6057000	139.2	12561.5
MIDDLETOWN PSYCHIATRIC CENTER	1	A	99 Other	EDGEMOORE IRON WORKS BOILER	68.1	15 STOKER NEC	4 BITUMINOUS COAL	5049000		
141 MONHAGEN AVE		B	99 Other	BOILER NO 4088 EDGEMOORE IRON	68.1	15 STOKER NEC	4 BITUMINOUS COAL	5049000		
MIDDLETOWN		C	99 Other	BOILER NO 4089 EDGEMOORE IRON	68.1	15 STOKER NEC	4 BITUMINOUS COAL	5049000		
MR. CHARLES DEHAVEN		D	99 Other	BOILER NO 4090 EDGEMOORE IRON	68.1	15 STOKER NEC	4 BITUMINOUS COAL	5049000	272.4	10098
								Region 3 Totals	528.8	25695.5

TABLE 3: NYSDEC SMS ANALYSIS FOR REGION 4 (For Non-utility Boilers Permitted to Use Coal

Fac. Name, Address, Contact Person	Emission Pt	Combustion Unit	Type	Manufacturer	Heat Input (MMBtu/hr)	Burner	Fuel	Fuel Quantity (Lb/year)	Total Heat Input (MMBtu/hr)	Total Coal Quantity (Tons/yr)
FORT ORANGE PAPER CO., INC	1	A	2 Built Up Boiler	RILEY STOKER CORPORATION #2853	70	19 ALL NOT LISTED	4 BITUMINOUS COAL	32600000	70	16300
1900 River Road										
CASTLETON										
ARNOLD SCHNEIDER, TECH DIRECTOR										
								Region 4 Totals	70	16300

TABLE 4: NYSDEC SMS ANALYSIS FOR REGION 6 (For Non-utility boilers Permitted to Use Coal)

Fac. Name, Address, Contact Person	Emission Pt	Combustion Unit	Type	Manufacturer	Heat Input (MMBtu/hr)	Burner	Fuel	Fuel Quantity (Lb/year)	Total Heat Input (MMBtu/hr)	Total Coal Quantity (Tons/yr)
FORT DRUM HTW COGEN FACILITY	1	A	2 Built Up Boiler	PYROPOWER CORP C.F.B.B	217	1 PULVERIZED DRY BOTTOM	1 ANTHRACITE COAL	14042667		
P.O.BOX 330						1 PULVERIZED DRY BOTTOM	4 BITUMINOUS COAL	118313333		
FORT DRUM		B	2 Built Up Boiler	PYROPOWER CORP C.F.B.B.	217	1 PULVERIZED DRY BOTTOM	1 ANTHRACITE COAL	14042667		
WILLIAM HANDEL						1 PULVERIZED DRY BOTTOM	4 BITUMINOUS COAL	118313333		
		C	2 Built Up Boiler	PYROPOWER CORP C.F.B.B	217	1 PULVERIZED DRY BOTTOM	1 ANTHRACITE COAL	14042667		
						1 PULVERIZED DRY BOTTOM	4 BITUMINOUS COAL	118313333		
						1 PULVERIZED DRY BOTTOM	WOOD	22600000	651	198534
CHAMPION INTERNATIONAL CORP	215	99	2 Built Up Boiler	COMBUSTION ENGINEERING VU	158.88	1 PULVERIZED DRY BOTTOM	4 BITUMINOUS COAL	82868400		
ANDERSON AVE	315	99	2 Built Up Boiler	COMBUSTION ENGINEERING VU	158.88	1 PULVERIZED DRY BOTTOM	4 BITUMINOUS COAL	82868400	317.76	82868.4
DEFERIET										
RICHARD WEBER										
AIR FORCE BASE CONVERSION AGEN	29A	A	2 Built Up Boiler	HENRY HOGT MACH CO MODEL VS	114	13 SPREADER STOKER /W REJ	4 BITUMINOUS COAL	7198000		
153 BROOKS ROAD		B	2 Built Up Boiler	HENRY HOGT MACH CO MODEL VS	114	13 SPREADER STOKER /W REJ	4 BITUMINOUS COAL	5528000		
ROME, NY	29B	A	2 Built Up Boiler	HENRY HOGT MACH CO MODEL VS	114	13 SPREADER STOKER /W REJ	4 BITUMINOUS COAL	4016000		
BASE CIVIL ENGINEER		B	2 Built Up Boiler	HENRY HOGT MACH CO MODEL VS	114	13 SPREADER STOKER /W REJ	4 BITUMINOUS COAL	11014000	456	13878
MOHAWK VALLEY PSYCHIATRIC CTR	1	A	2 Built Up Boiler	EDGEMORE IRON WORKS 201 A	25	15 STOKER NEC	1 ANTHRACITE COAL	3275000		
1400 NOYES AVE						15 STOKER NEC	1 ANTHRACITE COAL	3275000		
UTICA		B	2 Built Up Boiler	EDGEMOOR IRON WORKS 201 A	25	15 STOKER NEC	1 ANTHRACITE COAL	3275000		
ROBERT CORNISH						15 STOKER NEC	1 ANTHRACITE COAL	3275000		
		C	2 Built Up Boiler	EDGEMOOR IRON WORKS 201 A	25	15 STOKER NEC	1 ANTHRACITE COAL	3275000		
						15 STOKER NEC	1 ANTHRACITE COAL	3275000		
		D	2 Built Up Boiler	EDGEMOOR IRON WORKS 201 A	25	15 STOKER NEC	1 ANTHRACITE COAL	3275000		
						15 STOKER NEC	1 ANTHRACITE COAL	3275000	100	13100
								Region 6 Totals	1524.76	308380.4

TABLE 5: NYSDEC SMS ANALYSIS FOR REGION 7 (For Non-utility Boilers Permitted to Use Coal)

Fac. Name, Address, Contact Person	Emission Pt	Combustion Unit	Type	Manufacturer	Heat Input (MMBtu/hr)	Burner	Fuel	Fuel Quantity (Lb/year)	Total Heat Input (MMBtu/hr)	Total Coal Quantity Tons/yr)
SUNY AT BINGHAMTON	0001A	99	2 Built Up Boiler	INTERNATIONAL BOILER WORKS IN	59.3	15 STOKER NEC	4 BITUMINOUS COAL	3570000		
VESTAL PARKWAY EAST						62 FORCED DRAFT POWER	52 NATURAL GAS	47585106		
BINGHAMTON	0002A	99	2 Built Up Boiler	INTERNATIONAL BOILER WORKS IN	117.3	15 STOKER NEC	4 BITUMINOUS COAL	9476667		
RICHARD D LUCAS,						62 FORCED DRAFT POWER	52 NATURAL GAS	118458333		
DIR PHYSICAL PLANT	0003A	99	2 Built Up Boiler	INTERNATIONAL BOILER WORKS IN	117.3	15 STOKER NEC	4 BITUMINOUS COAL	9476667		
						62 FORCED DRAFT POWER	52 NATURAL GAS	118458333		
	0004A	99	2 Built Up Boiler	INTERNATIONAL BOILER WORKS IN	117.3	15 STOKER NEC	4 BITUMINOUS COAL	9476667		
						62 FORCED DRAFT POWER	52 NATURAL GAS	118458333	411.2	16000.0005
SALT CITY ENERGY VENTURE L P	1	A	2 Built Up Boiler	BABCOCK & WILCOX FH-26	275	1 PULVERIZED DRY BOTTOM	4 BITUMINOUS COAL	168000000		
56 INDUSTRIAL DR		B	2 Built Up Boiler	BABCOCK & WILCOX FH-26	275	1 PULVERIZED DRY BOTTOM	4 BITUMINOUS COAL	168000000		
SYRACUSE		C	2 Built Up Boiler	BABCOCK & WILCOX FH-26	275	1 PULVERIZED DRY BOTTOM	4 BITUMINOUS COAL	168000000		
LARRY LEUTHAUSER		D	2 Built Up Boiler	BABCOCK & WILCOX FH-26	275	1 PULVERIZED DRY BOTTOM	4 BITUMINOUS COAL	168000000		
		E	2 Built Up Boiler	BABCOCK & WILCOX FH-26	275	1 PULVERIZED DRY BOTTOM	4 BITUMINOUS COAL	168000000		
		F	2 Built Up Boiler	BABCOCK & WILCOX FH-26	275	1 PULVERIZED DRY BOTTOM	4 BITUMINOUS COAL	168000000	1650	504000
Delphi	96	99	2 Built Up Boiler	BABCOCK & WILCOX CO	75	15 STOKER NEC	4 BITUMINOUS COAL	7970000		
1000 TOWNLINE RD	97	99	2 Built Up Boiler	BABCOCK & WILCOX CO	75	15 STOKER NEC	4 BITUMINOUS COAL	7970000	150	7970
SALINA										
B KOCHEM 432-5197										
MILLER EASTERN BREWERY	11	99	2 Built Up Boiler	E KEELER CO BOILER NO 2	92.8	16 SPREADER STOKER /WO REJ	4 BITUMINOUS COAL	0		
P O BOX 2000						19 ALL NOT LISTED	36 NO 6 OIL - VIRGIN	1		
FULTON						52 STEAM ATOMIZED	52 NATURAL GAS	33600000		
KATHY KINTON	12	99	2 Built Up Boiler	E KEELER #3	92.8	16 SPREADER STOKER /WO REJ	4 BITUMINOUS COAL	2400000		
						19 ALL NOT LISTED	36 NO 6 OIL - VIRGIN	1		
						52 STEAM ATOMIZED	52 NATURAL GAS	1		
	25	99	2 Built Up Boiler	RILEY TYPE RX	238	1 PULVERIZED DRY BOTTOM	4 BITUMINOUS COAL	78388000		
						52 STEAM ATOMIZED	32 NO 2 OIL - VIRGIN	39717		
						62 FORCED DRAFT POWER	52 NATURAL GAS	1	423.6	40394
CU CENTRAL HEATING PLANT	1	C	2 Built Up Boiler	RILEY STOKER CORP 101-40 WW	249	5 PULVERIZED,WET /W REJ	4 BITUMINOUS COAL	8120000000		
DRYDEN ROAD	2	A	2 Built Up Boiler	ZURN TYPE SP-VC	117	13 SPREADER STOKER /W REJ	4 BITUMINOUS COAL	45000000	366	4082500
ITHACA										
HENRY E DONEY										
								Region 7 Totals	3000.8	4650864.001

TABLE 6: NYSDEC SMS ANALYSIS FOR REGION 8 (For Non-utility Boilers Permitted to Use Coal)

Fac. Name, Address, Contact Person	Emission Pt	Combustion Unit	Type	Manufacturer	Heat Input (MMBtu/hr)	Burner	Fuel	Fuel Quantity (Lb/year)	Total Heat Input (MMBtu/hr)	Total Coal Quantity (Tons/yr)
KODAK PARK DIV	1	E	2 Built Up Boiler	BABCOCK AND WILCOX S-9384	245	15 STOKER NEC	4 BITUMINOUS COAL	129348000		
1669 LAKE AVENUE		F	2 Built Up Boiler	BABCOCK AND WILCOX S-9384	245	15 STOKER NEC	4 BITUMINOUS COAL	129348000		
ROCHESTER	2	A	2 Built Up Boiler	BABCOCK & WILCOX S-8817	197	15 STOKER NEC	4 BITUMINOUS COAL	56590000		
DAVID M KISER		B	2 Built Up Boiler	BABCOCK & WILCOX S-9097	222	15 STOKER NEC	4 BITUMINOUS COAL	64096000		
		C	2 Built Up Boiler	BABCOCK & WILCOX RB-230	478	7	4 BITUMINOUS COAL	269470000		
						59 OTHER OIL ATOMIZER	36 NO 6 OIL - VIRGIN	629386		
	3	A	2 Built Up Boiler	BABCOCK AND WILCOX 5-10112	500	7	4 BITUMINOUS COAL	260000000		
						59 OTHER OIL ATOMIZER	36 NO 6 OIL - VIRGIN	140000		
		B	2 Built Up Boiler	BABCOCK & WILCOX S-10198	500	7	4 BITUMINOUS COAL	260000000		
						59 OTHER OIL ATOMIZER	36 NO 6 OIL - VIRGIN	140000		
	4	A	2 Built Up Boiler	BABCOCK & WILCOX S-10213	640	7	4 BITUMINOUS COAL	360000000		
						59 OTHER OIL ATOMIZER	36 NO 6 OIL - VIRGIN	180000		
		B	2 Built Up Boiler	COMBUSTION ENG MDL VU40	670	1 PULVERIZED DRY BOTTOM	4 BITUMINOUS COAL	379500000		
						59 OTHER OIL ATOMIZER	32 NO 2 OIL - VIRGIN	200000	3697	954176
GLEASON WORKS	103	99	1 Package Boiler	BABCOCK & WILCOX CLASS 30 #19	55.8	16 SPREADER STOKER /WO REJ	4 BITUMINOUS COAL	15262000		
1000 UNIVERSITY AVE	104	B	2 Built Up Boiler	BABCOCK & WILCOX #17387	25.7	16 SPREADER STOKER /WO REJ	4 BITUMINOUS COAL	302600	81.5	7782.3
ROCHESTER										
RONALD SWINK										
DELPHI ENERGY - LEXINGTON AVE	154	99	2 Built Up Boiler	B&W 2 DRUM STIRLING	74	16 SPREADER STOKER /WO REJ	4 BITUMINOUS COAL	28100000	74	14050
1000 LEXINGTON AVENUE										
ROCHESTER										
STEPHEN WOWKOWYCH										
IOLA STEAM GENERATING STATION	1	B	2 Built Up Boiler	B & W FF-16-48	50	13 SPREADER STOKER /W REJ	4 BITUMINOUS COAL	7200000		
444 E. HENRIETTA RD.						52 STEAM ATOMIZED	32 NO 2 OIL - VIRGIN	60000		
ROCHESTER, NY		C	2 Built Up Boiler	B & W FF-16-48	50	13 SPREADER STOKER /W REJ	4 BITUMINOUS COAL	9600000	100	8400
HENRY MANCZYK										
UNIVERSITY OF ROCHESTER	1	99	2 Built Up Boiler	BABCOCK & WILCOX STERLING MO	80	16 SPREADER STOKER /WO REJ	4 BITUMINOUS COAL	21575000		
ELMWOOD AVENUE	6	99	2 Built Up Boiler	BABCOCK & WILCOX MODEL SS 163	156.3	16 SPREADER STOKER /WO REJ	4 BITUMINOUS COAL	38254000		
ROCHESTER	7	99	2 Built Up Boiler	BABCOCK & WILCOX MODEL SS 163	156.3	16 SPREADER STOKER /WO REJ	4 BITUMINOUS COAL	38259000	392.6	49044
W. NICHOLS										
CARGILL SALT DIVISION	1	B	1 Package Boiler	ERIE CITY -2-DR-MP	80	13 SPREADER STOKER /W REJ	4 BITUMINOUS COAL	23805000		
518 E FOURTH STREET		C	1 Package Boiler	ERIE CITY -2-DR-MP	80	13 SPREADER STOKER /W REJ	4 BITUMINOUS COAL	23805000	160	23805
WATKINS GLEN										
JUAN REY										
								Region 8 Totals	4585.1	1057257.3

Fac. Name, Address, Contact Person	Emission Pt	Combustion Unit	Type	Manufacturer	Heat Input (MMBtu/hr)	Burner	Fuel	Fuel Quantity (Lb/year)	Total Heat Input (MMBtu/hr)	Total Coal Quantity Tons/yr)
SAMUEL CARLSON STATION	3	A	2 Built Up Boiler	COMBUSTION ENGINEERING CO #12	198	1 PULVERIZED DRY BOTTOM	4 BITUMINOUS COAL	80000000		
136 STEELE ST		D	2 Built Up Boiler	ERIE CITY IRON WORKS #97364	297	1 PULVERIZED DRY BOTTOM	4 BITUMINOUS COAL	63878000		
JAMESTOWN	4	B	2 Built Up Boiler	COMBUSTION ENGINEERING COMP	190	1 PULVERIZED DRY BOTTOM	4 BITUMINOUS COAL	51786000		
R JAMES GRONQUIST PE GEN MGR		C	2 Built Up Boiler	ERIE CITY IRON WORKS #95627	204	1 PULVERIZED DRY BOTTOM	4 BITUMINOUS COAL	21908000	889	108786
SUNY AT BUFFALO	1	A	2 Built Up Boiler	B & W SERIAL 8610B STIRLING	26.3	15 STOKER NEC	4 BITUMINOUS COAL	6279500		
220 WINSPEAR AVENUE		B	2 Built Up Boiler	B & W 8610A STIRLING	26.3	15 STOKER NEC	4 BITUMINOUS COAL	6279500		
BUFFALO		C	2 Built Up Boiler	B & W NO 20 STIRLING	39.3	15 STOKER NEC	4 BITUMINOUS COAL	6279500		
Gene Monacell		D	2 Built Up Boiler	B & W 21149 FP 18 #40	66.4	15 STOKER NEC	4 BITUMINOUS COAL	6279500	158.3	12559
SISTERS OF CHARITY HOSPITAL	0011C	A	1 Package Boiler	CNB T-600P-CA/G/04	25.1	15 STOKER NEC	4 BITUMINOUS COAL	9008000		
2157 MAIN ST						15 STOKER NEC	4 BITUMINOUS COAL	9008000		
BUFFALO						53 AIR ATOMIZED	34 NO 4 OIL - VIRGIN	40321.38		
JACOB E SCHU						62 FORCED DRAFT POWER	52 NATURAL GAS	502.32	25.1	9008
COLLINS CORRECTIONAL FACILITY	1	A	2 Built Up Boiler	BABCOCK & WILCOX CLASS XXII	16.2	15 STOKER NEC	4 BITUMINOUS COAL	8779120		
MIDDLE RD.		C	2 Built Up Boiler	BABCOCK & WILCOX CLASS XXII	16.2	15 STOKER NEC	4 BITUMINOUS COAL	8779120		
HELMUTH		D	2 Built Up Boiler	BABCOCK & WILCOX CLASS XXII	16.2	15 STOKER NEC	4 BITUMINOUS COAL	887760	48.6	9223
KEITH D. RUPERT										
UNITED DEVELOPMENT GP-NIAGARA	101	99	2 Built Up Boiler	UNDETERMINED	576.7	19 ALL NOT LISTED	4 BITUMINOUS COAL	357400000	576.7	178700
5400 FRONTIER AVENUE										
NIAGARA FALLS										
W J FAIR										
A. REF-FUEL EFS, 107, 109, 110	A0102	A	2 Built Up Boiler	RILEY STOKER CORP P8-35-WW	183	1 PULVERIZED DRY BOTTOM	4 BITUMINOUS COAL	70777152		
100 ENERGY BLVD @ 56TH ST						53 AIR ATOMIZED	32 NO 2 OIL - VIRGIN	18500		
NIAGARA FALLS		B	2 Built Up Boiler	RILEY STOKER CORP P8-35-WW	287	1 PULVERIZED DRY BOTTOM	4 BITUMINOUS COAL	79507968		
J WAFFENSCHMIDT						53 AIR ATOMIZED	32 NO 2 OIL - VIRGIN	18500		
	R1B02	99	2 Built Up Boiler	FOSTER WHEELER TYPE SF	468	13 SPREADER STOKER /W REJ	4 BITUMINOUS COAL	24000		
						52 STEAM ATOMIZED	34 NO 4 OIL - VIRGIN	278		
						62 FORCED DRAFT POWER	52 NATURAL GAS	165065000		
						69 OTHER NATURAL GAS TYPES	79 GAS - NEC	2700		
						71 GRAV FEED SCREW CONVEY	84 REFUSE DERIVED FUE	544380000	938	75154.56
MORTON SALT COMPANY	1	A	2 Built Up Boiler	RILEY STOKER CORP #3347	138	1 PULVERIZED DRY BOTTOM	4 BITUMINOUS COAL	54990000	138	27495
45 RIBAUD AVENUE										
SILVER SPRINGS								Region 9 Total	2773.7	428925.56
DAN BORDER										

SECTION 3:

THE PERSPECTIVES OF TECHNICAL EXPERTS FAMILIAR WITH INDUSTRIAL STOKER BOILERS

A variety of technical, economic, and management issues affect the overall viability of and interest in co-firing biomass in coal-fired industrial stoker boilers. Presented below is a summary of key issues, based on information provided by the Task Force on Biomass Co-Firing at Industrial Facilities formed for this study. Presented in Section 4 is a summary of key issues, based on interviews with energy managers or boilers operators at a sample of industries in New York State with boilers permitted to use coal. Taken together, the perspectives of both technical experts familiar with industrial boilers and co-firing and energy managers/boiler operators familiar with the challenges of running energy plants in multi-faceted industries provide important guidance on potential strategies for stimulating industrial co-firing in the future.

Stoker Boiler Type

The overall view of the Task Force is that coal-fired industrial stoker units with chain or travelling grates tend to be both "robust" in design and "forgiving" in their ability to burn fuels with varying characteristics, and are thus best suited for co-firing. Hand-fired or underfeed units are not suitable for co-firing.

Stoker Boiler Steam Flow and Heat Input

Industrial stoker units with capacity to generate at least 30,000 pounds of steam per hour are typically too large to be either hand-fired or underfeed units. Assuming stoker units require 1,000 Btu of fuel to generate a pound of steam, the steam flow equates to a boiler heat input of 30 MMBtu/hr.

Fuel Characteristics

Woodfuels and coal are very different. Industrial coal-fired boilers are typically designed to burn specific types of coal with a limited range of fuel characteristics. An issue with co-firing woodfuels with coal is the effect of the wood on the overall fuel characteristics. The change in fuel characteristics resulting from co-firing can significantly affect boiler performance and operation.

The view of the Task Force is that industrial stoker boilers tend to be fairly "robust" and "forgiving" in their design, and can readily absorb changes in fuel characteristics without large changes in performance and operation. The Task Force felt that as a rule-of-thumb, stoker units could probably co-fire up to 20-25% woodfuel on a weight basis. However, each boiler should be evaluated to determine its suitability

for co-firing. For instance, boiler height and residence time in some older stoker units may not be sufficient to achieve burnout of woodfuel particles that burn in suspension.

In addition, the operation of those boilers that are suitable to co-fire should be optimized to the co-fire fuel(s). For instance, the under- and over-fire air requirements will change due to the change in volatile matter and fixed carbon, and should be adjusted to optimize boiler performance and air emissions.

Ash Deposition

Similar to fuel characteristics, ash generated by the combustion of woodfuel is likely to be different than that generated by coal. The differences may include a reduction in the ash softening and fusion temperature, and the likelihood that ash will collect on boiler tubes and other surfaces. Ash deposition reduces heat transfer to the boiler tubes negatively impacting boiler efficiency and fuel use. In extreme cases, ash deposition results in slagging in which relatively large and often dangerous pieces of fused ash flow or drop off boiler tubes. Although ash deposition and slagging is primarily a fuel issue, boiler design and operation also affect the potential for either to occur. For instance, boilers that produce saturated steam (or hot water) are more likely to experience ash deposition/slagging than those that generate superheated steam due to lower boiler tube temperatures.

An issue with co-firing is the potential that even small amounts of wood in the fuel mix could cause detrimental or dangerous slagging. Various fuel analyses (such as alkali content) indicate the relative potential for ash deposition and slagging. However, it is not possible to accurately estimate ash deposition and slagging potential based on these indicators since none can account for the influence of the boiler. The best method to determine if co-firing will lead to ash deposition or slagging is to conduct test burns. However, it is the overall opinion of the Task Force that as long as the co-fire rate is kept below 20-25% on a weight basis, ash deposition or slagging should not be a problem.

Air Regulations

It is generally believed by the Task Force members that increased concern about air emissions from coal-fired industrial boilers could stimulate interest in co-firing in the industrial sector. In New York, for example, state air regulations for lead, mercury, and NOx could become much stricter during the next few years and according to Robert Warland, Director of Air Resources within the New York State Department of Environmental Conservation, "Coal-burning will be under siege in New York during the next five years." In addition (and as noted in Section 1), co-firing will also result in the reduction of both SOx and CO2.

Similar to SOx, lead and mercury emissions are dependent on the amount of the metal that enters the boiler as fuel. Since wood contains only trace amounts of lead and mercury, co-firing should reduce the emission of the two metals by an amount proportional to the co-firing rate.

The emission of NOx is different, since NOx is formed during the combustion process from nitrogen contained in both fuel and combustion air. Co-firing woodfuels is believed to have NOx benefits in many coal-fired boilers due to woodfuel's lower flame temperature than that of coal. However, flame temperature is only one of many factors that can affect NOx formation, and in some situations co-firing may result in NOx increases. The Electric Power Research Institute, U.S. Department of Energy, Federal Energy Technology Center, and other agencies and organizations are analyzing the impacts of co-firing on air emissions. Preliminary results indicate that NOx emissions tend to decrease in utility-scale cyclone and pulverized coal boiler co-firing at rates of up to 20% of the total heat input. Co-firing tests in smaller, stoker-fed units indicates greater decreases in NOx emission in spreader-stoker units than in underfeed, chaingrate units. However, the decreases are described as "trimming" and are not necessarily enough to achieve NOx reductions required by potential future air regulations.

Boiler Planning

Several Task Force members noted the time frame used by industry for site and facilities planning is not ideal for stoker boilers. Concerns about labor costs, product demand, and other factors prevent many industries from committing to specific manufacturing plants and facilities for more than 5 years. However, the life of the boiler, as well as the life span of maintenance or upgrade projects/programs typically exceed 5 years. Industry is often not willing to fund boiler maintenance or upgrade projects since the projects are not financial advantageous when using the 5 year payback period.

Boiler Maintenance and Operator Experience

Several members of the Task Force noted a decline in both industrial stoker boiler maintenance and operator experience. They believe that overall industrial stoker boilers are not well maintained. They also believe that availability of experienced boiler operators is rapidly declining. The decline in maintenance and operator experience may be a result of industry focusing on producing products and not believing there is a near term (i.e. the five year planning period discussed above) benefit from boiler maintenance and operator training. The Task Force also noted that some stoker boiler parts are either no longer available or hard to get, further compounding the problem.

Heating and Process Steam Demands

Ideal industrial boilers for co-firing will have constant and predictable heat and/or process steam demands. This allows the boiler to be operated with minimal manpower and reduces the wear and tear caused by constantly changing boiler parameters to follow changing steam demands. An ideal situation for co-firing is a steam demand that remains constant for at least 90% of the time.

However, it is possible to co-fire successfully at facilities with variability in steam demand, especially if increases in demand coincide with seasonal increases in biomass fuel availability. For example, there may

be an effective match between an increased demand for steam during the winter (due to space heating requirements) when woodfuel is available, and decreased demand for steam during the spring and summer when other markets for wood waste (such as mulch) increase.

Cost of Natural Gas

Several Task Force members noted that although natural gas costs significantly more than coal on a $/MMBtu basis, when operating and maintenance costs are taken into account natural gas can be financially attractive. General rules-of-thumb are the "burner tip" cost of natural gas is about $3/MMbtu, while the overall cost of burning coal is about $4/MMbtu, which includes $2/MMbtu to purchase the coal and $2/MMbtu for boiler labor and maintenance.

The Availability of Natural Gas

Industries, businesses, and other facilities located in areas that do not have access to natural gas are generally more likely to be interested in alternative fuel options, such as co-firing, than those that already have access to natural gas. Research conducted by the Gas Research Institute indicates that, nationwide:

- 44% of industries and other facilities with coal-fired stokers do not have natural gas on-site;
- 38% have natural gas on-site but do not have the burners needed to use the gas; and
- 18% have and use natural gas.

For those with access to natural gas, their supplier may require the industry to agree to a contract that allows the supplier to interrupt the supply of gas (depending on regional supply of and demand for the fuel) or to pay a higher fee for an uninterruptable supply. This can be a deterrent for companies that do not have the flexibility to substitute other fuels for natural gas during periods of interruptable supply.

The use of natural gas continues to increase throughout New York and many portions of the Northeast region as new pipelines are built, service territories are extended, and high efficiency/low emissions gas-fired boilers are widely available. Yet, many rural areas in New York State and northern portions of the Northeast are not currently served by existing pipelines and new pipelines are not yet proposed.

The Availability of Biomass Fuel

Numerous assessments of the availability of biomass for fuel in New York State and the Northeast region overall indicate that, in general, the supply of biomass greatly exceeds the demand. For instance, the study Waste Wood Resource Supply Assessment published by NYSERDA in August 1991 estimated the quantity of wood waste generated in New York to be 12 million tons in 1989. Of this, an estimated 4

million tons were used for fuel or other purposes, or recycled in some way, indicating that about 8 million tons per year could potentially be available for fuel (based on 1989 data). The study further notes that the amount of wood potentially available as fuel could exceed 8 million tons per year if markets for the material existed.

Key factors affecting the potential to co-fire are the price of biomass fuel and the infrastructure used to supply it to end users. Biomass fuel prices depend on a wide variety of factors, and typically coal users expect the biomass to be available at a cost (expressed in terms of $/MMBtu of energy) that is not greater (and ideally less) than the price of coal.

SECTION 4:

THE PERSPECTIVES OF MANAGERS/OPERATORS OF COAL-FIRED INDUSTRIAL BOILERS IN NEW YORK

Interviews were conducted with energy managers or boiler operators at industries in New York State in order to learn directly from them key issues affecting their interest in and ability to co-fire biomass. A sample of 10 industries identified in the SMS database query as having coal-fired boilers with a combined heat input of at least 50,000 MMBtu/hr were asked to participate in an interview. They represented a cross-section of industry types, boiler sizes, and locations. Of the 10 industries contacted, six were interested in participating in interviews. However, two of the six (The Gleason Works and the Middletown Psychiatric Center) had previously converted to another fuel. Another industry with coal-fired boilers was not interested in participating in a full interview, but provided limited information on their operation and boilers. Detailed interviews were conducted with representatives of the remaining four industries in the sample, including:

- **Cargill Inc.**, a salt extraction and refining operation in Watkins Glen. The salt is extracted by "solution mining" and is recovered by evaporation. The evaporators are heated by steam. The company operates four boilers, two of which are 75,000 pph coal-fired stoker units. The other two are natural gas units. The company purchases about 24,000 tons of coal annually.

- **Fort Drum Cogeneration Partners**, which operates a coal-fired cogeneration plant in Fort Drum. The plant sells steam to the Fort Drum military base, and electricity is sold on the open market through a broker. The net electrical generating capacity is 55 MW. The plant operates four circulating fluidized bed boilers. The contract with Fort Drum requires co-firing of wood waste. Coal use is about 200,000 tons per year, and wood use is about 10,000 tons per year.

- **The Eastman Kodak Company** (Kodak), which operates a large industrial campus in Rochester. The company has nine coal-fired boilers, four of which are stoker units. However, two of the stoker units were recently shut down, and the remaining two continue to operate. The four stoker units are rated at about 200,000 pph each. The five other boilers are either pulverized coal or cyclone units. The steam generated is used primarily for space heating, process heat, or refrigeration. The company also generates a small amount of electrical power through back-pressure turbines. Total coal use is about 700,000 tons annually.

- **State University of New York at Binghamton** (SUNY Binghamton), which operates four coal-fired stoker units. The units provide high temperature hot water for space heating. The hot water is distributed to various buildings through underground piping. Between 1985 and 1994, SUNY Binghamton completed major rehabilitation of the four boilers, which included adding natural gas burners. However, the ability to add to the underground distribution system is limited, and new or increased space heating demands are met with small, distributed natural gas-fired package boilers. Current coal use is about 7,000 tons per year.

Presented below is a summary of key issues affecting industrial interest in co-firing raised during interviews with energy managers or boiler operators at industries and other non-utility facilities in New York. Overall, the interviews indicate much of the technical information provided by the Task Force applies to industrial boilers in New York. However, the industrial representatives emphasized that key barriers affecting biomass co-firing in industrial coal-fired boilers are: cost; impacts on boiler operation and maintenance; and a lack of interest in benefits provided by co-firing.

Conversion to Natural Gas or Oil rather than to Co-fire Biomass

The decision to convert to or add new natural gas-fired boilers at a coal-fired industrial boiler is driven by both cost considerations and the impact on air emissions. When developing future plans for boilers, careful attention is paid to the capital, operating, and maintenance costs as well as fuel costs. Natural gas is generally perceived by industrial managers as being able to lower overall boiler costs since it reduces operating and maintenance costs.

For example, The Gleason Works (a heavy manufacturing industry in Rochester) recently installed two package natural gas boilers to replace two coal-fired stoker units. The coal-fired units are maintained as back-up units. According to a company representative, the reason for the conversion was primarily cost with the net present value of natural gas being lower than coal. Most other industrial representatives interviewed agree that the "burner tip" cost of natural gas compared to the cost of coal is a major factor in their decision whether to use natural gas or coal. For instance, the use of natural gas or coal at SUNY Binghamton is dependent on cost. When natural gas is less expensive than coal, gas is used. When coal is less expensive, it is used.

Representatives of SUNY Binghamton note that during low demand periods (such as during the summer) coal use results in blue smoke. The representative from Cargill notes their two coal-fired boilers are operated at the same time only when the combined emissions remain within permit limits. When the Middletown Psychiatric Center was under a mandate from the NYSDEC to reduce emissions, they chose mobile oil-fired units to replace their coal-fired stoker units.

Boiler Maintenance, Operation, and Planning

According to industrial managers interviewed for this study, industrial boilers (including stoker units) in New York State are well maintained and operated, and are integral to a company's short-and long-range planning efforts. The four industries interviewed indicated their boilers are critical to their process or mission and that because of this, both short- and long-term plans for the boilers have been developed and are being carried out. This is demonstrated by SUNY Binghamton, which spent about $10 million between 1985 and 1994 upgrading its coal-fired boilers.

Industrial Interest in Co-Firing

Both Kodak and SUNY Binghamton have co-fired woodfuels in the past with less than positive results. Fort Drum Cogeneration Partners is required to co-fire as part of its steam sales contract with the military base.

Overall, the industries interviewed are not greatly interested in or supportive of co-firing biomass. Most of the staff interviewed expressed concerns that any benefit of co-firing would be outweighed by increased capital, operating, and maintenance costs associated with receiving, processing, and burning woodfuels. They indicated the price of woodfuels will have little impact on their interest in co-firing, even if available at a price that is lower than the price of coal (on a $/MMBtu basis). This is because they believe co-firing will increase capital, operating, and maintenance costs, and the increase in these costs is more important than possible decreases in fuel costs. In addition, everyone interviewed said factors such as locally produced renewable fuels and greenhouse gas reductions have little, if any, impact on company policy concerning fuel procurement.

Industrial Interest in Co-firing Technical Assistance Programs

During the interviews, industrial managers were asked about the types of technical or financial assistance programs that would assist them in investigating or using biomass as co-fire fuel. None of the staff interviewed expressed interest in technical or financial programs, citing concerns about a lack of staff time and resources as well as concerns about increased capital, operating, and maintenance costs when co-firing as the primary reasons. They noted that if an industry does co-fire, it would need to happen in a way that has minimal, if any, impact on staff time, capital costs, operating and maintenance costs, and fuel procurement costs. This presents a problem for the typical approach used by utilities to co-fire (for example) in which they usually receive, convey, store, process, and burn woodfuels separately from coal. This approach increases the amount (and cost) of equipment, labor, and energy needed to handle woodfuels. Interviews conducted for this study indicate industry is unwilling to incur these costs based on what they perceive as the benefits (or lack of benefits) of co-firing.

SECTION 5:

STRATEGIES TO INCREASE BIOMASS CO-FIRING IN INDUSTRIAL BOILERS IN THE NORTHEAST

The Northeast Regional Biomass Program could provide a valuable role in stimulating interest in co-firing in industrial coal-fired stoker boilers in the Northeast. Suggested below are several activities the NRBP could initiate to promote and encourage industrial co-firing in the region. The next steps described below are designed to take advantage of the NRBP's 15-year history providing technical assistance and technology transfer activities to industries, businesses, and public agencies on a wide range of biomass energy issues.

Increase Awareness of and Commitment to Co-Firing in Non-Utility Boilers

To date, interest in co-firing has primarily been limited to the electric utility sector, with limited interest shown among industries, institutions, public agencies, and other coal-fired facilities. Part of the reason for this is key players involved in promoting co-firing have targeted electric utilities due to the tremendous benefits co-firing can achieve at large coal-fired utility power plants. The benefits of co-firing in smaller boilers in the industrial, institutional, and governmental sectors have largely been overlooked. One strategy for overcoming the lack of interest in co-firing among these facilities is for key players such as the U.S. DOE, Federal Energy Management Program (FEMP), Council of Industrial Boilers (CIBO), and others to support and promote co-firing in non-utility boilers.

To Target Industrial Boilers, Work with the Stoker Efficiency Network: The Stoker Efficiency Network (SEN) is a trade association established to increase the efficiency of industrial, institutional, commercial, and utility stoker-fired boilers primarily as a way to extend their life and also as a way to reduce energy costs, reduce emissions, increase reliability, and increase safety. According to Dale Smith, Director of the Network (and a member of the Task Force formed for this project), co-firing biomass in stoker boilers is one of many techniques that can be used to achieve the Network's goals. The Network organizes a Stoker Boiler Efficiencies and Life Extension Workshop twice a year and is interested in holding the next workshop in the Northeast. Targeted specifically at industries with stoker-fired boilers, the workshop is one way of reaching industrial managers from throughout the region. The NRBP could co-sponsor a workshop with the Network and assist in offering it at a site in the Northeast that is centrally-located to the highest concentration of coal-fired industrial stoker boilers. Possible locations could include central Pennsylvania or Maryland, for example.

To Target Federal Boilers, Work with FEMP and NREL to Identify Co-Fire Opportunities in the Northeast: The U.S. DOE's Office of Energy Efficiency and Renewable Energy Federal Energy Management Program was created to assist federal facilities in complying with requirements of the

Energy Policy Act of 1992 and Executive Order 12902, both of which require federal agencies to reduce energy consumption at federal facilities. While compliance with both the Act and the Executive Order are key goals of FEMP, its overall mission is broader and includes reducing the cost of government by advancing energy efficiency and using renewable energy. The National Renewable Energy Laboratory provides technical assistance to FEMP and identifies financing incentives for implementing energy reduction programs.

There are a multitude of ways in which the NRBP, FEMP, and NREL could work together to advance co-firing at federal facilities in the Northeast. It is beyond the scope of this project to complete a detailed survey of FEMP and NREL programs or initiatives in which the NRBP could assist or collaborate. However, information provided at FEMP's website (http://eren.doe.gov/femp) and NREL's FEMP website (http://nrel/gov/femp) indicate one collaborative project could be to identify federal facilities with coal-fired stoker boilers and to perform the Federal Renewable Energy Screening Assistant (FRESA) analysis to determine which facilities appear most promising regarding co-firing. If the FRESCA results are promising, more detailed analysis could be done to identify which co-firing scenarios would be the most economically and environmentally-friendly.

Another collaborative project could be to expand FEMP's Greening Federal Facilities resource guide (http://eren.doe.gov/femp/greenfed) to include a detailed section on biomass fuels and co-firing at coal-fired boilers. The guide suggests biomass-fired boilers should be considered (Section 3.2.1 Boilers) and further suggests that because renewable resources are pollution-free, they have a significant advantage when environmental impacts are considered (Section 3.10 Renewable and Alternative Energy Systems). However, the guide does not mention co-firing as an option, nor does it include information on the environmental benefits of biomass fuels compared to fossil fuels. Considering that the guide's purpose is to assist federal energy managers in reducing the environmental impact of energy production and use at federal facilities, inclusion of these two subjects is appropriate and important.

Research and Identify Candidate Industrial Boilers

An important step when seeking to increase interest in industrial co-firing is to determine key characteristics that affect the ability to co-fire and to then research and identify those companies and boilers that could have potential for co-firing. Presented below is a summary of key criteria to use when researching and identifying candidate facilities with potential for co-firing in the future. Information in the table is based on the perspectives provided by technical experts who participated on the Task Force on Biomass Co-firing at Industrial Facilities as well as energy managers/boiler operators interviewed for this study. Although it is difficult to generalize about the characteristics and situations that lend themselves to successful co-firing, the table provides general guidance that can assist in beginning the research and identification of candidate facilities.

TABLE 8: KEY CHARACTERISTICS FOR IDENTIFYING CANDIDATE FACILITIES

CHARACTERISTICS	COMMENTS
Boiler Type	Stoker units are most suitable.
Boiler Size	>30,000 pph steam flow.
Steam Demand Fluctuations	Boilers should not experience high fluctuations in demand. Boiler with greater than 90% constant demand are ideal.
Woodfuel Cost	≤ coal on a $/MMbtu basis.
Availability of Natural Gas	Limited availability may increase interest in co-firing.
Air Emissions	States may increase restrictions on industrial sources of lead, mercury, SOx, and NOx. Co-firing may reduce these emissions.
Industry Environmental Stewardship Goals	Companies and institutions with specific environmental stewardship goals may be more likely to consider co-firing biomass (or using other renewable fuels).

Publish and Distribute a Written Briefing on Co-Firing for Industrial Representatives

In general, industry representatives are largely unaware of the benefits of co-firing. To facilitate interest in and to provide good information about co-firing in industrial coal-fired boilers, a briefing could be prepared for industrial representatives and public policymakers on the energy, environmental, and economic benefits of co-firing wood fuel. The benefits could be compared to those associated with converting coal-fired industrial boilers to natural gas. Such a briefing could describe the experience to date co-firing in industrial boilers, the ready made co-fire fuel concept, potential suppliers of ready-made co-fire fuels, air emissions benefits of co-firing, etc. The briefing could be distributed to industries identified as candidate facilities as well as to public policymakers and federal and state energy staff.

Provide Ready-Made Co-Fire Fuels to Industrial Boilers in the Northeast

Overall, the industries interviewed indicated they are not supportive of co-firing due to the capital, operating, and maintenance costs associated with receiving, processing, and burning woodfuels. One approach for stoker-fired and possibly cyclone industrial boilers to co-fire without increased cost is for "ready-made" co-fire fuels (consisting of the appropriate mix of coal and woodfuel) to be delivered in a form that is ready to burn.

In this approach, the ready-made fuel would be accepted, conveyed, and stored in the same way as coal. Since the user would not handle the co-fire fuel differently than coal, there would be little, if any, need

for additional equipment or labor. Assuming the price of the co-fire fuel is the same as coal, the overall cost of co-firing for an industry should be similar to that for coal. (This approach will likely not work at industries that burn pulverized coal, since the coal is first pulverized in mills located on-site. The overall experience at utility power plants that pulverize mixtures of coal and wood is that it limits pulverizer capacity and increases energy use, both of which are undesirable. For this reason most, if not all, utility power plants that co-fire wood with pulverized coal store, process, convey, and burn woodfuels separately from coal.)

There could be two problems associated with the ready-mix co-fire fuel concept. The first is that the woodfuel could become segregated from the coal during transportation, conveying, and storage. Because coal and wood have different densities, these activities could cause woodfuels to "float" on top of the coal. The ultimate problem with segregation is that inconsistent mixtures of coal and woodfuel could be delivered to the boiler, resulting in uneven performance and fluctuations in steam generation. It is likely that co-fire fuel segregation could be rectified by strategically placing relatively simple mixing equipment. It should be noted that supplying a ready-mix co-fire fuel has been tried on a demonstration basis. Dr. James Cobb of the University of Pittsburgh is directing a demonstration project to co-fire woodfuel in coal-fired boilers at the Pittsburgh Brewing Company in Pittsburgh, Pennsylvania. In order to provide the co-fire fuel, Dr. Cobb enlisted the support of Pittsburgh Brewing Company's coal supplier as well as a local pallet recycler. Ground used pallets were layered with coal when loading trucks used to supply coal to the brewery. Mixing occurred during routine unloading and transfer of the fuel. During the test burns, the fuel mixture was not observed to segregate, nor were fluctuations in boiler performance experienced.

The NRBP could develop or be a key player in a program to provide ready-made co-fire fuels to industrial stoker-fired coal units in the Northeast. The program would enlist the support of coal suppliers to provide the co-fire fuel. The program would also provide technical expertise to evaluate potential boilers and optimize boiler performance when using co-fire fuels. Other key players who might provide financial or technical support include the U.S. DOE Office of Industrial Technologies, the U.S. DOE Federal Energy Technology Center, the U.S. Department of Agriculture Forest Service, the Council of Industrial Boiler Owners, as well as coal-related trade associations.

The overall purpose of the program would be to build support for and interest in industrial co-firing by demonstrating that co-firing at stoker-fired units is not only technically feasible, but can be done in a manner that has little, if any, impact on energy production at industrial sites. If the program is to work, it must make co-firing at industrial stoker units as easy and cost-effective as possible. In order to do this, the program would consist of three features or steps:

- Identification and selection of candidate boilers for co-firing;

- Providing ready-made co-fire fuel at the same price as coal, or perhaps a slightly lower price (on a $/MMBtu basis); and

- Providing training to boiler operators to maximize boiler performance when using the co-fire fuel.

Key to the program idea is the concept of ready-made co-fire fuel, which is based on Dr. Cobb's work investigating co-firing at the Pittsburgh Brewing Company. Similarly, the NRBP program would involve enlisting the support of coal suppliers, such as United Pittsburgh Coal. United Pittsburgh Coal is a relatively large coal supplier and broker who supplies customers not only in Pennsylvania but also in New York, for example. According to Bruce Rosen, President of United Pittsburgh, the company would be interested in supplying ready-made co-fire fuels to other customers on a long-term basis (providing there is sufficient market demand as well as profit potential). Mr. Rosen further notes the company would be willing to work with entities such as the NRBP to provide ready-made co-fire fuels on a trial or temporary basis.

Also key to the program idea is providing technical expertise to evaluate candidate boilers and to optimize boiler performance on the ready-made co-fire fuel. The expertise is needed to ensure the boilers are capable of properly burning co-fire fuel, since some stoker-fired coal boilers are not appropriate for biomass fuels. Prior to burning co-fire fuel, all boilers included in the program should be inspected to ensure they are appropriate. The boiler expertise is also needed to ensure that once the co-fire fuel is used, the operation of each boiler is optimized to the new fuel. This expertise could be provided by FETC personnel or a private firm specializing in coal-fired stoker boiler design and operation.

SECTION 6:

SUGGESTED NEXT STEPS FOR NYSERDA

In addition to regional activities that could be undertaken by the Northeast Regional Biomass Program, a variety of state-specific initiatives could be undertaken to stimulate interest in co-firing in industrial coal-fired stoker boilers in individual states. Presented below are several next steps the New York State Energy Research and Development Authority could undertake to promote and encourage industrial co-firing in New York State. They are designed to take advantage of NYSERDA's role in offering energy services and the agency's long history in facilitating biomass energy use in the state.

Participate in Regional Efforts to Provide Ready-Made Co-fire Fuel to Non-Utility Boilers

NYSERDA could participate in and assist with regional efforts to provide ready-made co-fire fuel and technical assistance to non-utility boilers in a variety of ways. For example, NYSERDA could:

- Provide financial assistance to a regional or federal ready-made co-fire fuel demonstration project.

- Provide in-kind assistance to a regional ready-made co-fire fuel demonstration project. For example, NYSERDA could work with the NYSDEC Division of Air Resources to modify air permits or complete other authorizations necessary to test burn co-fire fuels in industrial boilers. NYSERDA could also take the lead in identifying and enlisting the support of a state facility (or facilities) to participate in a co-firing demonstration project.

- Provide the technical expertise necessary to evaluate and optimize boilers to co-fire woodfuel. This may involve contracting with private consultants or federal agencies, such as the U.S. DOE's Federal Energy Technology Center.

- Fund projects that evaluate industrial boilers when operating on co-fire fuels and compare them to boilers that only burn coal. This could include documenting the air emissions, ash emissions, boiler efficiency, and other boiler performance characteristics, for example.

- Publish and distribute results of industrial co-firing projects using ready-made fuels to other industries as a way of educating them about co-firing and stimulating their interest in co-firing.

Explore Co-Fire Opportunities with NYSERDA's Energy Efficiency Services

Co-firing in industrial boilers can be viewed as a strategy to increase energy efficiency since it reduces demand for nonrenewable fossil fuel energy for space heating and process steam while reducing emissions of CO2, SO2, and possibly NOx. The benefits of co-firing match well with the goals of NYSERDA's Energy Efficiency Services, suggesting the service could participate in a program to support co-firing at

an industry or state facility. Specifically, the State Energy Investment Program could be utilized to invest in the facilities or infrastructure necessary to co-fire at a state university, hospital, or other large facility.

Help Fund an Industrial Co-Fire Demonstration Project

NYSERDA could help fund one or more state facilities to co-fire on a demonstration or trial basis. The purpose would be to demonstrate the technical viability of co-firing and to serve as a high-profile educational project. The state facility (or facilities) could include a state university, public hospital, or other large public facility with one or more coal-fired stoker boilers.

Co-Sponsor and/or Host a Stoker Efficiency Network Workshop in New York State

NYSERDA could seek to co-sponsor and/or host one of the workshops offered periodically by the Stoker Efficiency Network. This could be done in collaboration with the NRBP, if desired, or separately. If a workshop is held in New York State, it might be possible to include on the agenda issues specific to New York.