11 Other Fuels and Fuel Emission Factor Assumptions

Besides coal (chapter 9) and natural gas (chapter 10) EPA Base Case v.4.10 also includes assumptions for residual fuel oil, biomass, nuclear fuels, and various waste fuels. The assumptions described in this chapter pertain to fuel characteristics, fuel market structures, and fuel prices for these fuels. As seen in the previous chapter, there is an endogenous resource costing model for natural gas built into EPA Base Case v.4.10. Coal is represented via an elaborate set of supply curves and a detailed representation of the associated coal transport network. Together they are designed to capture the intricacies of the resource base and market for this fuel which currently powers about 45% of U.S. electric generating capacity. As with coal, the price and quantity of biomass combusted is determined by balancing supply and demand using a set of geographically differentiated supply curves. In contrast, fuel oil and nuclear fuel prices are exogenously determined and entered into IPM during model set-up as constant price points which apply to all levels of supply. Generally, the waste fuels are also modeled using price points. In this chapter each of the remaining fuels is treated in turn. The chapter concludes with a discussion of the emission factors for all the fuels represented in EPA Base Case v.4.10.

11.1 Fuel Oil

Two petroleum derived fuels are included in EPA Base Case v.4.10: As its name implies distillate fuel oil is distilled from crude oil, whereas residual fuel oil is left as a residue of the distillation process. The fuel oil prices in EPA Base Case v.4.10 are from AEO 2010 and are shown in Table 11-1. They are regionally differentiated according to the NEMS (National Energy Modeling System) regions used in AEO 2010 and are mapped to their corresponding IPM regions for use in EPA Base Case v.4.10.

Table 11-1 Fuel Oil Prices by NEMS Region in EPA Base Case v.4.10

Residual Fuel Oil Prices (2007$/MMBtu)					
NEMS Region	**2012**	**2015**	**2020**	**2030**	**2040 - 2050**
ECAR	16.40	30.04	41.07	54.20	63.77
ERCOT	20.00	21.96	23.40	25.42	26.91
MAAC	9.85	11.84	13.63	15.65	17.05
MAIN	91.20	104.84	115.87	129.00	138.57
MAPP	17.14	8.61	8.61	8.61	16.19
NY	9.63	11.73	13.59	15.61	16.99
NE	9.80	11.91	13.77	15.80	17.19
FL	10.50	12.48	13.92	15.95	17.44
SERC	10.96	12.83	14.28	16.32	17.81
SPP	17.36	21.73	23.15	25.14	26.60
NWP	19.56	21.58	23.06	25.00	26.50
RA	19.68	21.67	23.14	25.09	26.59
CA	21.63	23.83	25.10	27.24	28.56

Distillate Fuel Oil Prices (2007$/MMBtu)					
NEMS Region	**2012**	**2015**	**2020**	**2030**	**2040 - 2050**
ECAR	14.8	16.96	19.87	22.25	24.19
ERCOT	14.75	16.86	19.71	22.09	24.03
MAAC	14.82	16.99	19.9	22.3	24.25
MAIN	14.86	17.04	19.94	22.31	24.24
MAPP	14.88	17.05	19.95	22.32	24.25
NY	14.87	17.05	19.98	22.38	24.33
NE	15.07	17.23	20.13	22.53	24.49

Distillate Fuel Oil Prices (2007$/MMBtu)					
NEMS Region	2012	2015	2020	2030	2040 - 2050
FL	14.67	16.78	19.65	22.04	23.99
SERC	14.65	16.8	19.69	22.08	24.03
SPP	14.8	16.93	19.8	22.18	24.12
NWP	15.84	17.85	20.29	22.84	24.74
RA	15.59	17.73	20.6	23.02	24.97
CA	16.21	17.95	19.99	22.66	24.53

11.2 Biomass

Biomass is offered as a fuel for existing dedicated biomass power plants and potential (new) biomass direct fired boilers (built by the model prior to 2020) and to potential (new) biomass gasification combined cycle units built by the model from 2020 forward. (See chapter 4 for a presentation of the cost and performance characteristics for these two technologies.) In addition to its use as the prime mover fuel for these plants, it is also offered for co-firing to all coal fired power plants. (See section 5.3 for a discussion of the representation of biomass co-firing in EPA Base Case v.4.10.) As noted in the discussion in chapter 5, the combustion of biomass fuel is considered to have a net zero impact on atmospheric carbon dioxide levels since the emissions released are equivalent in carbon content to the carbon absorbed during fuel crop growth[1].

EPA Base Case v.4.10 uses biomass supply curves based on those in AEO 2010. There are fourteen regional biomass fuel supply curves, one for each of the 14 NEMS coal demand regions represented in AEO 2010. Plants demand biomass from the supply curve corresponding to the NEMS coal demand region in which they are located. No inter-regional trading of biomass is allowed. Each biomass supply curve depicts the price-quantity relationship for biomass and varies over time. There is a separate curve for each model run year. The supply component of the curve represents the aggregate supply in a region of four types of biomass fuels: forestry residue, agricultural residue, urban wood waste, and mill residue and energy crops. The price component of the curve includes transportation cost and represents the delivered fuel cost at the plant gate. The original AEO 2010 supply curves contained 48 price steps, and are modeled as-is in EPA Base Case v.4.10. Appendix 11-1 contains the 2012-2035 biomass supply curves.

The supply curves in Appendix 11-1 represent the biomass available to both the electric and non-electric sectors. In any given region at any point in time the power sector demand from IPM has to be combined with the non-electric sector demand for biomass to obtain the price faced by the power sector. The non-electric sector demand distribution is by NEMS coal demand region based on AEO 2010. The total national projection from AEO 2010 was scaled up to the projections obtained from the Forest and Agricultural Sector Optimization Model (FASOM), a dynamic, nonlinear programming model of the U.S. forest and agricultural sectors developed for EPA by Bruce A. McCarl, Professor of Agricultural Economics at Texas A&M University. Table 11-2 shows the non-electric sector demand by run year and NEMS region.

Table 11-2 Non-Electric Biomass Demand by NEMS Region in EPA Base Case v.4.10

Non-Electric Biomass Demand (TBtu)						
NEMS Coal Demand Region		2012	2015	2020	2030	2040 - 2050
1	CT, MA, ME, NH, RI, and VT	--	--	--	17.1	15.7
2	NY, PA, and NJ	--	--	--	--	0.0
3	WV, MD, DC, DE, VA, NC, and SC	19.4	126.7	336.1	354.1	324.2
4	GA and FL	12.7	80.3	201.7	202.4	185.3

[1]Hughes, E., Role of Renewables in Greenhouse Gas Reduction, Electric Power Research Institute (EPRI): November, 1998. Report TR-111883, p. 28.

Non-Electric Biomass Demand (TBtu)						
NEMS Coal Demand Region		2012	2015	2020	2030	2040 - 2050
5	OH	--	--	--	--	0.0
6	IN, IL, MI, and WI	--	--	--	--	0.0
7	KY and TN	--	--	--	--	0.0
8	AL and MS	--	--	--	--	0.0
9	MN, IA, ND, SD, NE, MO, and KS	131.8	184.3	63.8	48.0	43.9
10	TX, LA, OK, and AR	0.9	0.3	0.1	0.1	0.1
11	MT, WY, and ID	0.4	0.1	0.0	13.2	12.1
12	CO, UT, and NV	0.3	0.1	0.0	11.8	10.8
13	AZ and NM	0.3	0.1	0.0	9.0	8.2
14	WA, OR, and CA	0.2	22.7	506.7	467.6	428.1

Once the non-electric demand for biomass is factored in, biomass prices in EPA Base Case v.4.10 are derived endogenously based on the aggregate power sector demand for biomass in each region. The results are unique market-clearing prices for each supply region. All plants using biomass from that supply region face the same market-clearing price.

11.3 Nuclear Fuel

The AEO 2009 price assumption for nuclear fuel is used as the nuclear fuel price assumption for 2012-2050 in EPA Base Case v.4.10. The 2012, 2015, 2020, and 2030 prices are 0.71, 0.75, 0.76, and 0.84 lbs/MMBtu, respectively.

11.4 Waste Fuels

Among the “modeled fuels” shown for existing generating units in the NEEDS, v.4.10 (the database which serves as the source of data on existing units for EPA Base Case v.4.10) are a number of waste fuels, including waste coal, petroleum coke, fossil waste, non-fossil waste, tires, and municipal solid waste (MSW). Table 11-3 describes these fuels, shows their extent of their representation in NEEDS, and then indicates the assumptions adopted in EPA Base Case v.4.10 to represent their use and pricing. It should be noted that these fuels are only provided to existing and planned committed units in EPA Base Case v.4.10. Potential new generating units that the model “builds” are not given the option to burn these fuels. In IPM reported output, tires, MSW, and non-fossil waste are all included under existing non-fossil other, while waste coal and petroleum coke is included under coal.

Table 11-3 Waste Fuels in NEEDS, v.4.10 and EPA Base Case v.4.10

Modeled Fuel in NEEDS	Number of Units in NEEDS	Total Capacity in NEEDS	Description	Supply and Cost	
				Modeled By	Assumed Price
Waste Coal	3	2,205 MW	"Usable material that is a byproduct of previous coal processing operations. Waste coal is usually composed of mixed coal, soil, and rock (mine waste). Most waste coal is burned as-is in unconventional fluidized-bed combustors. For some uses, waste coal may be partially cleaned by removing some extraneous noncombustible constituents. Examples of waste coal include fine coal, coal obtained from a refuse bank or slurry dam, anthracite culm, bituminous gob, and lignite waste." http://www.eia.doe.gov/glossary/index.cfm?id=W	Supply Curve Based on AEO 2010	AEO 2010
Petroleum Coke	29	3,442 MW	A residual product, high in carbon content and low in hydrogen, from the cracking process used in crude oil refining	Price Point	$42.24/ MMBtu
Fossil Waste	28	982 MW	Waste products of petroleum or natural gas including blast furnace and coke oven gas. They do not include petroleum coke or waste coal which are specified separately among the "Modeled Fuels"	Price Point	0
Non-Fossil Waste	66	874 MW	Non-fossil waste products that do not themselves qualify as biomass. These include waste products of liquid and gaseous renewable fuels (e.g., red and black liquor from pulping processes, digester gases from waste water treatment). They do not include urban wood waste which is included in biomass.	Price Point	0
Tires	3	44 MW	Discarded vehicle tires.	Price Point	0
Municipal Solid Waste	183	2,197 MW	"Residential solid waste and some nonhazardous commercial, institutional, and industrial wastes." http://www.eia.doe.gov/glossary/index.cfm	Price Point	0

11.5 Fuel Emission Factors

Table 11-4 brings together all the fuel emission factor assumptions as implemented in EPA Base Case v.4.10. For sulfur dioxide and mercury in coal, where emission factors vary widely based on the rank, grade, and supply seam source of the coal, cross references are given to tables that provide more detailed treatment of the topic. Nitrogen oxides (NO_X) are not included in Table 11-4 because NO_X levels are not primarily fuel based but are a factor of the combustion process.

Table 11-4 Fuel Emission Factor Assumptions in EPA Base Case v.4.10

Fuel Type	Heat Content (Btu/lb)[1]	Carbon Dioxide (lbs/MMBtu)[2]	Sulfur Dioxide (lbs/MMBtu)[3]	Mercury (lbs/TBtu)[3]
Coal				
Bituminous	>10,260 - 13,000	205.2 - 206.6	0.67 - 6.43	1.82 - 34.71
Subbituminous	> 7,500 - 10,260	212.7 - 213.1	0.58 - 1.41	4.24 - 6.44
Lignite	< 7,500	213.5 - 217.0	1.46 - 3.91	7.51 - 14.88
Natural Gas	--	117.08	0	0.00014
Fuel Oil				
Distillate	--	161.4	0	0.48
Residual	--	161.4 - 173.9	0.3 - 2.65	0.48
Biomass	--	0	0.08	0.57
Waste Fuels				
Waste Coal	6,175	205.7	5.36	63.9
Petroleum Coke	14,150	225.1	7.27	23.18
Fossil Waste	--	321.1	0.08	0
Non-Fossil Waste	--	0	0	0
Tires	--	189.5	1.65	3.58
Municipal Solid Waste	--	91.9	0.35	71.85

Notes:

[1]Distillate and Residual Oils, Biomass, Fossil Waste, Non-Fossil Waste, Tires, and Municipal Solid Waste (MSW) are priced at a $/MMBtu basis and hence heat content is not required for modeling.

[2]Also see Table 9-9

[3]Also see Table 9-6, and Table 9-7

Biomass fuel is considered to have a net zero impact on atmospheric carbon dioxide levels since the emissions released are equivalent in carbon content to the carbon absorbed during fuel crop growth. (See, for example, Hughes, E., Role of Renewables in Greenhouse Gas Reduction, Electric Power Research Institute (EPRI): November, 1998. Report TR-111883, p. 28.)

"Biomass Co-firing," Chapter 2 in *Renewable Energy Technology Characterizations*, U.S. Department of Energy and Electric Power Research Institute (EPRI), 1997.

Analysis of Emissions Reduction Option for the Electric Power Industry, Office of Air and Radiation, U.S. Environmental Protection Agency, March 1999.

Appendix 11-1 Biomass Supply Curves in EPA Base Case v.4.10

This is a small excerpt of the data in Appendix 11-1. The complete data set in spreadsheet format can be downloaded via the link found at www.epa.gov/airmarkets/progsregs/epa-ipm/BaseCasev410.html

Year	Biomass Supply Region	Step Name	Cost of Production (2007$/MMBtu)	Biomass Production (TBtu/Year)
2012	AL, MS	BM01	0.00	0
2012	AL, MS	BM02	1.83	21.28
2012	AL, MS	BM03	2.12	21.04
2012	AL, MS	BM04	2.39	19.44
2012	AL, MS	BM05	2.68	13.27
2012	AL, MS	BM06	2.97	10.35
2012	AL, MS	BM07	3.26	7.33
2012	AL, MS	BM08	3.54	78
2012	AL, MS	BM09	3.83	2.95
2012	AL, MS	BM010	4.11	1.22
2012	AL, MS	BM011	4.40	0.2
2012	AL, MS	BM012	4.68	0
2012	AL, MS	BM013	4.97	0
2012	AL, MS	BM014	5.26	0
2012	AL, MS	BM015	5.54	0
2012	AL, MS	BM016	5.82	0
2012	AL, MS	BM017	6.11	0
2012	AL, MS	BM018	6.40	0
2012	AL, MS	BM019	6.82	5
2012	AL, MS	BM020	7.24	5
2012	AL, MS	BM021	7.66	5
2012	AL, MS	BM022	8.07	5
2012	AL, MS	BM023	8.49	5
2012	AL, MS	BM024	8.91	5
2012	AL, MS	BM025	9.33	5
2012	AL, MS	BM026	9.76	5
2012	AL, MS	BM027	10.18	5
2012	AL, MS	BM028	10.60	5
2012	AL, MS	BM029	11.02	5
2012	AL, MS	BM030	11.44	5
2012	AL, MS	BM031	11.86	5
2012	AL, MS	BM032	12.28	5
2012	AL, MS	BM033	12.70	5
2012	AL, MS	BM034	13.12	5
2012	AL, MS	BM035	13.54	5
2012	AL, MS	BM036	13.97	5
2012	AL, MS	BM037	14.38	5
2012	AL, MS	BM038	14.80	5
2012	AL, MS	BM039	15.22	5
2012	AL, MS	BM040	15.64	5