11. Other Fuels and Fuel Emission Factor Assumptions

Besides coal (chapter 9) and natural gas (chapter 10), EPA Base Case v.5.13 also includes assumptions for residual fuel oil, distillate 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.5.13. 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 these fuels which accounted for about 68% of U.S. electric generation in 2012. 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.5.13.

11.1 Fuel Oil

Two petroleum derived fuels are included in EPA Base Case v.5.13. 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.5.13 are from AEO 2013 and are shown in Table 11-1. They are regionally differentiated according to the NEMS (National Energy Modeling System) regions used in AEO 2013 and are mapped to their corresponding IPM regions for use in EPA Base Case v.5.13.

Table 11-1 Fuel Oil Prices by NEMS Region in EPA Base Case v.5.13

Residual Fuel Oil Prices (2011$/MMBtu)						
NEMS Region	**2016**	**2018**	**2020**	**2025**	**2030**	**2040 - 2050**
ERCT	21.94	26.06	30.09	41.37	53.54	82.89
FRCC	16.93	21.06	25.09	36.37	48.54	77.88
MROE	83.45	87.58	91.61	102.89	115.05	144.40
MROW	20.32	24.45	28.48	39.76	51.92	81.27
NEWE	11.00	11.65	12.27	14.04	24.33	23.74
NYCW	12.29	12.94	13.56	15.33	17.50	22.14
NYLI	12.29	12.94	13.56	15.33	17.50	22.14
NYUP	12.29	12.94	13.56	15.33	17.50	22.14
RFCE	15.05	16.02	16.63	19.13	21.30	25.94
RFCM	92.33	96.45	100.48	111.76	123.93	153.28
RFCW	84.13	88.26	92.29	103.57	115.73	145.08
SRDA	20.92	25.05	29.08	40.36	52.52	81.87
SRGW	83.45	87.58	91.61	102.89	115.05	144.40
SRSE	16.09	20.22	24.25	35.53	47.69	77.04
SRCE	82.14	86.26	90.29	101.57	113.74	143.09
SRVC	16.09	16.74	17.36	19.13	31.30	60.65
SPNO	20.32	24.45	28.48	39.76	51.92	81.27
SPSO	21.94	26.06	30.09	41.37	53.54	82.89
AZNM	21.94	26.06	30.09	41.37	53.54	82.89
CAMX	10.31	14.44	18.47	29.75	41.91	71.26
NWPP	24.78	25.46	26.07	28.17	30.15	34.93
RMPA	83.91	88.03	92.06	103.34	115.51	144.86

Distillate Fuel Oil Prices (2011$/MMBtu)						
NEMS Region	**2016**	**2018**	**2020**	**2025**	**2030**	**2040 - 2050**
ERCT	21.40	22.17	22.96	25.13	27.30	32.56
FRCC	21.56	22.35	23.13	25.29	27.46	32.72
MROE	20.44	21.23	22.01	24.18	26.43	31.68
MROW	20.09	20.90	21.69	23.85	26.04	31.30
NEWE	21.17	21.96	22.75	24.91	27.08	32.34
NYCW	20.36	21.15	21.93	24.09	26.26	31.52
NYLI	20.36	21.15	21.93	24.09	26.26	31.52
NYUP	20.36	21.15	21.93	24.09	26.26	31.52
RFCE	20.74	21.53	22.33	24.48	26.68	31.94
RFCM	20.44	21.23	22.01	24.18	26.43	31.68
RFCW	20.67	21.46	22.25	24.41	26.63	31.89
SRDA	21.40	22.17	22.96	25.13	27.30	32.56
SRGW	20.40	21.19	21.97	24.14	26.38	31.63
SRSE	21.32	22.08	22.86	25.03	27.19	32.46
SRCE	20.92	21.70	22.48	24.64	26.83	32.09
SRVC	21.56	22.35	23.13	25.29	27.46	32.72
SPNO	20.07	20.86	21.64	23.80	25.98	31.25
SPSO	21.31	22.08	22.87	25.04	27.21	32.47
AZNM	22.08	23.01	23.73	25.88	28.13	33.29
CAMX	21.76	22.75	23.47	25.62	27.87	33.02
NWPP	21.68	22.61	23.41	25.55	27.81	32.97
RMPA	22.08	23.01	23.73	25.88	28.13	33.29

11.2 Biomass

Biomass is offered as a fuel for existing dedicated biomass power plants and potential (new) biomass direct fired boilers. 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.5.13.)

EPA Base Case v.5.13 uses biomass supply curves based on those in AEO 2013. These NEMS-coal demand region level supply curves are translated into state-level supply curves for use in EPA Base Case v.5.13 using proportions developed from agricultural statistic district (ASD) level intermediate AEO 2011 biomass supply curves. Plants demand biomass from the supply curve corresponding to the state in which they are located. No inter-state 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. Each supply curve contains 74 price steps for each run year. The supply component of the curve represents the aggregate supply in each state of four types of biomass fuels: urban wood waste and mill residue, public forestry residue, private forestry residue and agricultural residue[121]. The price component of the curve includes transportation costs, which AEO[122] assumed to be $12/ dry ton for all four biomass types in all states. The supply curves represent the state-specific delivered biomass fuel cost at the plant gate. IPM adds a storage cost of $20/dry ton to each step of the agricultural residue supply curves to reflect the limited agricultural growing season[123].

[121] The AEO 2013 biomass supply is described in the NEMS *Renewable Fuels Module* documentation, http://www.eia.gov/forecasts/aeo/assumptions/pdf/renewable.pdf

[122] http://www.eia.gov/forecasts/aeo/nems/documentation/renewable/pdf/m069(2013).pdf, p. 83.

[123] http://www.extension.iastate.edu/agdm/crops/pdf/a1-22.pdf , http://www.rand.org/content/dam/rand/pubs/technical_reports/2011/RAND_TR876.pdf

Excerpt from Table 11-2 Biomass Supply Curves in EPA Base Case v.5.13

This is a small excerpt of the data in Excerpt from Table 11-2. The complete data set in spreadsheet format can be downloaded via the link found at www.epa.gov/airmarkets/progsregs/epa-ipm/BaseCasev513.html

Year	Biomass Supply Region	Step Name	Cost of Production (2011$/MMBtu)	Biomass Production (TBtu/Year)
2016	AL	BM01	0	0
2016	AL	BM02	1.42	0.87
2016	AL	BM03	1.74	0
2016	AL	BM04	2.06	25.12
2016	AL	BM05	2.38	0
2016	AL	BM06	2.71	29
2016	AL	BM07	3.03	0
2016	AL	BM08	3.35	2.44
2016	AL	BM09	3.67	0
2016	AL	BM10	3.79	0
2016	AL	BM11	4.00	2.78
2016	AL	BM12	4.13	0.23
2016	AL	BM13	4.32	0
2016	AL	BM14	4.48	2.59
2016	AL	BM15	4.64	3.83
2016	AL	BM16	4.82	0.89
2016	AL	BM17	4.96	0
2016	AL	BM18	5.16	0.28
2016	AL	BM19	5.28	9.94
2016	AL	BM20	5.51	0.24
2016	AL	BM21	5.61	0
2016	AL	BM22	5.85	0.53
2016	AL	BM23	5.93	18.47
2016	AL	BM24	6.19	0.13
2016	AL	BM25	6.25	0.74
2016	AL	BM26	6.54	0
2016	AL	BM27	6.57	0.74
2016	AL	BM28	6.88	0
2016	AL	BM29	6.89	0.74
2016	AL	BM30	7.22	0.74
2016	AL	BM31	7.22	0.14
2016	AL	BM32	7.54	0.74
2016	AL	BM33	7.57	0.07
2016	AL	BM34	7.86	0.74
2016	AL	BM35	7.91	0.10
2016	AL	BM36	8.18	0.74
2016	AL	BM37	8.25	0
2016	AL	BM38	8.51	0.74
2016	AL	BM39	8.60	0
2016	AL	BM40	8.83	0.74
2016	AL	BM41	8.94	0
2016	AL	BM42	9.15	0.74
2016	AL	BM43	9.28	0.28
2016	AL	BM44	9.47	0.74
2016	AL	BM45	9.62	0
2016	AL	BM46	9.79	0.74
2016	AL	BM47	9.97	0
2016	AL	BM48	10.12	0.74

Year	Biomass Supply Region	Step Name	Cost of Production (2011$/MMBtu)	Biomass Production (TBtu/Year)
2016	AL	BM49	10.31	0
2016	AL	BM50	10.44	0.74
2016	AL	BM51	10.65	0
2016	AL	BM52	10.76	0.74
2016	AL	BM53	11.00	0
2016	AL	BM54	11.08	0.74
2016	AL	BM55	11.34	0
2016	AL	BM56	11.41	0.74
2016	AL	BM57	11.68	0.13
2016	AL	BM58	11.73	0.74
2016	AL	BM59	12.03	0
2016	AL	BM60	12.05	0.74
2016	AL	BM61	12.37	0
2016	AL	BM62	12.37	0.74
2016	AL	BM63	12.69	0.74
2016	AL	BM64	13.02	0.74
2016	AL	BM65	13.34	0.74
2016	AL	BM66	13.66	0.74
2016	AL	BM67	13.98	0.74
2016	AL	BM68	14.31	0.74
2016	AL	BM69	14.63	0.74
2016	AL	BM70	14.95	0.74
2016	AL	BM71	15.27	0.74
2016	AL	BM72	15.59	0.74
2016	AL	BM73	15.92	0.74
2016	AL	BM74	16.24	0.74

The supply curves in Excerpt from Table 11-2 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 census division based on AEO 2013**.** Table 11-3 shows the non-electric sector demand by run year and census divisions.

Table 11-3 Non-Electric Biomass Demand by Census Division in EPA Base Case v.5.13

Non-Electric Biomass Demand (TBtu)							
	Census Division	2016	2018	2020	2025	2030	2040-2050
1	CT, MA, ME, NH, RI, and VT	--	--	--	1.87	0.80	0.51
2	NJ, NY, and PA	--	0.0004	1.70	1.76	1.62	1.15
3	IL, IN, MI, OH, and WI	2.16	2.16	1.16	0.26	2.06	9.01
4	IA, KS, MN, MO, ND, NE, and SD	5.74	5.74	3.07	0.70	0.22	0.14
5	DE, FL, GA, MD, NC, SC, VA, and WV	6.80	6.80	5.13	7.69	5.38	3.98
6	AL, KY, MS, and TN	--	--	--	--	2.92	1.71
7	AR, LA, OK, and TX	1.08	1.08	0.58	0.13	2.33	1.34
8	AZ, CO, ID, MT, NM, NV, UT, and WY	1.10	1.10	0.59	0.13	0.89	0.53
9	CA, OR, and WA	2.70	2.70	7.35	7.02	3.35	1.19

Once the non-electricity demand for biomass is factored in, biomass prices in EPA Base Case v.5.13 are derived endogenously based on the aggregate power sector demand for biomass in each state. The results are unique market-clearing prices for each state. All plants using biomass from that state face the same market-clearing price.

11.3 Nuclear Fuel

The AEO 2013 price assumption for nuclear fuel is used as the nuclear fuel price assumption for 2016-2050 in EPA Base Case v.5.13. The 2016, 2018, 2020, 2025, 2030 and 2040 prices are 0.89, 0.90, 0.90, 0.96, 1.01 and 1.06 2011 $/MMBtu, respectively.

11.4 Waste Fuels

Among the "modeled fuels" shown for existing generating units in the NEEDS v.5.13 (the database which serves as the source of data on existing units for EPA Base Case v.5.13), are a number of waste fuels, including waste coal, petroleum coke, fossil waste, non-fossil waste, tires, and municipal solid waste (MSW). Table 11-4 describes these fuels, shows the extent of their representation in NEEDS, and then indicates the assumptions adopted in EPA Base Case v.5.13 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.5.13. 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 are included under coal.

Table 11-4 Waste Fuels in NEEDS v.5.13 and EPA Base Case v.5.13

NEEDS				Supply and Cost	
Modeled Fuel	Number of Units	Capacity (MW)	Description	Modeled By	Assumed Price
Waste Coal	27	2,432	"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 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.gov/tools/glossary/index.cfm?id=W	Supply Curve Based on AEO 2013	AEO 2013
Petroleum Coke	22	3,170	A residual product, high in carbon content and low in hydrogen, from the cracking process used in crude oil refining	Price Point	$83.3/Ton
Fossil Waste	60	412	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	143	1,600	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	2	46	Discarded vehicle tires.	Price Point	0
Municipal Solid Waste	179	2,279	"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 11-5 brings together all the fuel emission factor assumptions as implemented in EPA Base Case v.5.13. For sulfur dioxide, chlorine, 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 11-5 because NO_x emissions are a factor of the combustion process, and are not primarily fuel based.

Table 11-5 Fuel Emission Factor Assumptions in EPA Base Case v.5.13

Fuel Type		Carbon Dioxide (lbs/MMBtu)	Sulfur Dioxide (lbs/MMBtu)[a]	Mercury (lbs/TBtu)[a]	HCl (lbs/MMBtu)[a]
Coal					
	Bituminous	202.8 - 209.6	0.67 - 6.43	1.82 - 26.07	0.005 - 0.280
	Subbituminous	209.2 - 215.8	0.58 - 1.90	2.03 - 8.65	0.006 - 0.014
	Lignite	212.6 - 219.3	1.46 - 5.67	7.51 - 30.23	0.011 - 0.036
Natural Gas		117.1	0	0.00014	0
Fuel Oil					
	Distillate	161.4	0 - 2.65	0.48	0
	Residual	173.9	1.04	0.48	0
Biomass		--[b]	0.08	0.57	0
Waste Fuels					
	Waste Coal	204.7	7.14	63.9	0.0921
	Petroleum Coke	225.1	7.27	2.66[c]	0.0213
	Fossil Waste	321.1	0.08	0	0
	Non-Fossil Waste	0	0	0	0
	Tires	189.5	1.65	3.58	0
	Municipal Solid Waste	91.9	0.35	71.85	0

Notes:

[a] Also see Table 5-9

[b] CO_2 emissions from biomass are not currently included in EPA Base Case v.5.13. CO_2 emission factors are not currently available for the four aggregate biomass fuels used in the biomass supply representation in EPA Base Case v. 5.13. EPA is currently developing methods to estimate the amount of CO_2 emitted on-site during biomass co-firing at coal fired power plants.

[c] A previous computational error in the mercury emission factor for petroleum coke as presented in Table 6-3 of the EPA report titled Control of Mercury Emissions from Coal-fired Electric Utility Boilers: Interim Report Including Errata, 3-21-02 was corrected (from 23.18 lbs/TBtu to 2.66 lb/TBtu) based on re-examination of the 1999 ICR data for petroleum coke and implementation of a procedure for flagging and excluding outlier values above the 95 percentile value.