9.   Other Fuels and Fuel Emission Factor Assumptions

Besides coal (Chapter 7) and natural gas (Chapter 8), EPA 2023 Reference Case also includes assumptions for residual fuel oil, distillate fuel oil, biomass, nuclear, and waste fuels. This chapter describes the assumptions pertaining to the characteristics, market structures, and prices of these other fuels. As reported in previous chapters, natural gas is represented by an exogenous supply curve along with a basis differential approach informed by a resource fundamentals model. Coal is represented by a robust 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 62% of U.S. electric generation in 2019.[79] As with coal, the price and quantity of biomass combusted are determined by balancing supply and demand using a set of geographically differentiated supply curves. In contrast, fuel oil, nuclear, waste fuel, and hydrogen prices are exogenously determined and input to IPM during model set-up as constant price points that apply to all levels of supply. The following sections treats each of these remaining fuels and concludes with a discussion of the emission factors for all the fuels represented in the EPA 2023 Reference Case.

9.1   Fuel Oil

Two petroleum-derived fuels are included in EPA 2023 Reference Case. Distillate fuel oil is distilled from crude oil, and residual fuel oil is a residue of the distillation process. The fuel oil prices are based on the AEO 2023 reference case projection and a long-term crude oil projection of 64 $/barrel and are shown in Table 9-1. They are regionally differentiated according to the National Energy Modeling System (NEMS) regions used in the AEO 2023. These prices are mapped to their corresponding IPM regions for use in the EPA 2023 Reference Case.

Table 9-1 Fuel Oil Prices by NEMS Region in the EPA 2023 Reference Case

Residual Fuel Oil Prices (2022$/MMBtu)							
AEO NEMS Region	2028	2030	2035	2040	2045	2050	2055
TRE	13.37	13.49	13.82	13.64	12.65	12.72	12.72
FRCC	13.37	13.49	13.82	13.64	12.65	12.72	12.72
MISW	13.37	13.49	13.82	13.64	12.65	12.72	12.72
MISC	9.59	9.76	10.20	10.21	10.21	10.12	10.12
MISE	13.37	13.49	13.82	13.64	12.65	12.72	12.72
MISS	13.37	13.49	13.82	13.64	12.65	12.72	12.72
ISNE	13.37	13.49	13.82	13.64	12.65	12.72	12.72
NYCW	9.85	13.49	13.82	10.48	10.55	10.47	10.47
NYUP	10.58	10.75	11.20	11.21	11.29	11.21	11.21
PJME	10.58	10.75	11.20	11.21	11.29	11.21	11.21
PJMW	10.12	10.29	10.74	10.74	10.82	10.74	10.74
PJMC	13.37	13.49	13.82	13.64	12.65	12.72	12.72
PJMD	13.37	13.49	13.82	13.64	12.65	12.72	12.72
SRCA	13.37	13.49	13.82	13.64	12.65	12.72	12.72
SRSE	13.37	13.49	13.82	13.64	12.65	12.72	12.72
SRCE	13.37	13.49	13.82	13.64	12.65	12.72	12.72
SPPS	13.37	13.49	13.82	13.64	12.65	12.72	12.72
SPPC	13.37	13.49	13.82	13.64	12.65	12.72	12.72
SPPN	13.37	13.49	13.82	13.64	12.65	12.72	12.72
SRSG	13.37	13.49	13.82	13.64	12.65	12.72	12.72
CANO	13.37	13.49	13.82	13.64	12.65	12.72	12.72
CASO	13.37	13.49	13.82	13.64	12.65	12.72	12.72
NWPP	13.37	13.49	13.82	13.64	12.65	12.72	12.72

---

[79] EIA. Detailed EIA-923 monthly and annual survey data back to 1990. Available at https://www.eia.gov/electricity/data.php#generation

Residual Fuel Oil Prices (2022$/MMBtu)							
RMRG	9.85	10.00	10.36	10.44	10.58	10.49	10.49
BASN	13.37	13.49	13.82	13.64	12.65	12.72	12.72

Distillate Fuel Oil Prices (2022$/MMBtu)							
AEO NEMS Region	2028	2030	2035	2040	2045	2050	2055
TRE	16.77	16.90	17.37	17.30	17.31	17.10	17.10
FRCC	19.71	19.78	20.22	20.14	20.21	20.02	20.02
MISW	15.07	15.14	15.57	15.49	15.56	15.37	15.37
MISC	15.16	15.21	15.66	15.60	15.68	15.53	15.53
MISE	15.02	15.09	15.51	15.43	15.51	15.31	15.31
MISS	16.77	16.90	17.37	17.30	17.31	17.10	17.10
ISNE	17.32	17.40	17.84	17.75	17.83	17.63	17.63
NYCW	21.65	21.73	22.16	22.08	22.16	21.96	21.96
NYUP	18.68	18.99	19.24	19.10	19.06	21.96	21.96
PJME	21.36	21.36	21.80	21.67	21.74	21.43	21.43
PJMW	17.76	18.51	19.53	19.36	19.44	19.25	19.25
PJMC	18.68	18.99	19.24	19.10	19.06	19.02	19.02
PJMD	19.71	19.78	20.22	19.10	19.06	19.02	19.02
SRCA	19.71	19.78	20.22	20.14	20.21	20.02	20.02
SRSE	16.95	16.77	17.21	17.13	17.47	17.31	17.31
SRCE	16.70	16.77	17.21	17.13	17.15	16.94	16.94
SPPS	16.77	16.90	17.37	17.30	17.31	17.10	17.10
SPPC	15.08	15.15	15.58	15.49	15.57	15.37	15.37
SPPN	15.08	15.15	15.58	15.49	15.57	15.37	15.37
SRSG	20.57	20.72	20.96	20.93	21.02	20.86	20.86
CANO	19.45	19.54	20.01	19.95	20.05	19.86	19.86
CASO	19.45	19.54	20.01	19.95	20.05	19.86	19.86
NWPP	19.57	19.56	20.02	19.97	20.09	19.90	19.90
RMRG	20.63	20.73	21.19	21.14	21.22	21.02	21.02
BASN	20.63	20.73	21.19	21.14	21.22	21.02	21.02

9.2   Biomass Fuel

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 coal-fired power plants that have co-fired biomass in the recent past. Section 5.3 provides further details of these selected plants.

EPA 2023 Reference Case uses biomass supply curves based on those in the Department of Energy's 2016 Billion-Ton Report (DOE Report). Biomass supply curves at the IPM region and state level are generated by aggregating county-level supply curves from the DOE Report. Power plants demand biomass from the supply curve corresponding to the IPM region and state in which they are located. No inter-region 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 each region of agricultural residues, forestry residues, energy crops, waste, and trees. The price component of the curve includes transportation costs of $15 per dry ton.   The supply curves represent the IPM region, and state-specific delivered biomass fuel cost at the plant gate. A storage cost of $20 per dry ton is added to each step of the agricultural residue supply curves to reflect the limited agricultural growing season.[80] The biomass

---

[80] 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

supply curves are summarized in Table 9-4. The biomass prices are derived endogenously based on the aggregate power sector demand for biomass in each IPM region and state. The results are unique market-clearing prices for each IPM region and state. All plants using biomass from that IPM region and state face the same market-clearing price.

9.3   Nuclear Fuel

The AEO 2023 price for nuclear fuel is used as the nuclear fuel price assumption in EPA 2023 Reference Case. The 2028, 2030, 2035, 2040, 2045, and 2050 prices are 0.71 2022 $/MMBtu, respectively.

9.4   Waste Fuels

The waste fuels include waste coal, petroleum coke, fossil waste, non-fossil waste, tires, and municipal solid waste (MSW). Table 9-2 describes the characteristics of these fuels, the extent to which they are represented in NEEDS, and the assumptions pertaining to their use and pricing. Furthermore, the fuels are provided to only existing and planned-committed generating units. Potential (new) generating units that the model builds are not given the option to burn these fuels. In the IPM model output, tires, MSW, and non-fossil waste are included under existing non-fossil other plant type, while waste coal and petroleum coke are included under coal plant type.

Table 9-2 Waste Fuels in the EPA 2023 Reference Case

Modeled Fuel in NEEDS	Number of Units in NEEDS	Total Capacity in NEEDS	Description	Supply and Cost	
				Modeled By	Assumed Price
Waste Coal	18	1,364 MW	"Waste coal is a usable material that is a byproduct of previous coal processing operations. It is usually composed of mixed coal, soil, and rock (mine waste). Most waste coal is burned as-is in unconventional fluidized-bed combustors. Waste coal may be partially cleaned by removing some extraneous noncombustible constituents. Waste coal includes fine coal, coal obtained from a refuse bank or slurry dam, anthracite culm, bituminous gob, and lignite waste." https://www.eia.gov/tools/glossary/index.php?id=W	Supply Curve Based on AEO 2023	AEO 2023
Petroleum Coke	11	1,114 MW	A residual product, high in carbon content and low in hydrogen, from the cracking process used in crude oil refining.	Price Point	$56.44/Ton
Fossil Waste	54	1,071 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	201	2,136 MW	Non-fossil waste products that do not qualify as biomass. These include waste products of liquid and gaseous renewable fuels (e.g., red, and black liquor from pulping processes and digester gases from wastewater treatment). They do not include urban wood waste which is included in biomass.	Price Point	0
Tires	1	26 MW	Discarded vehicle tires.	Price Point	0
Municipal Solid Waste	147	1,913 MW	Residential solid waste and some nonhazardous commercial, institutional, and industrial wastes. https://www.eia.gov/tools/glossary/index.php?id=M	Price Point	0

9.5   Hydrogen Fuel

The price of hydrogen is assumed to be 9.64 $/MMBtu.

9.6   Fuel Emission Factors

Table 9-3 brings together all the fuel emission factor assumptions implemented in EPA 2023 Reference Case. For sulfur dioxide, chlorine, and mercury in coal, where emission factors vary widely based on the rank, grade, and supply 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 9-3 because NO_x emissions are a factor of the combustion process and are not primarily fuel based.

Table 9-3 Fuel Emission Factor Assumptions in the EPA 2023 Reference Case

Fuel Type	Carbon Dioxide (lbs/MMBtu)	Sulfur Dioxide (lbs/MMBtu)	Mercury (lbs/TBtu)	HCl (lbs/MMBtu)
Coal				
Bituminous	202.8 - 212.9	0.67 - 7.78	2.80 - 34.71	0.015 - 0.214
Subbituminous	209.2 - 215.7	0.52 - 2.15	2.03 - 8.65	0.007 - 0.014
Lignite	212.6 - 219.3	1.51 - 5.67	7.53 - 30.23	0.011 - 0.036
Natural Gas	117.08	0	0.00014	0
Fuel Oil				
Distillate	161.39	0	0.48	0
Residual	173.91	1.04	0.48	0
Biomass	195	0.08	0.57	0
Waste Fuels				
Waste Coal	204.7	7.78	53.9	0.0921
Petroleum Coke	225.1	7.70	2.66	0.0213
Fossil Waste	321.0	0.08	0	0
Non-Fossil Waste	0	0	0	0
Tires	189.5	1.65	3.58	0.06
Municipal Solid Waste	91.9	0.35	71.85	0

Note:

Table 7-4 has coal emission factor on a coal supply region level.

List of tables that are uploaded directly to the web:

Table 9-4 Biomass Supply Curves for EPA 2023 Reference Case