annual weighted thermal efficiency over time for 13 years. I don't see any seasonal trend in efficiency. So 13 years along the x axis and a zigzag line for each generation type.

Same kind of graph for CD/MWh.

Rich,

Let's look at the trend through 156 months for each of 9 generation types. A seasonal effect would show as little waves, but we are mostly interested in a long-term trend. We're also interested in unusual spikes indicating funny data in one month. As you can see from the examples (see attached), we can really only plot one gen type on each graph, or maybe two using a secondary y axis, or else temporal change will be harder to see.

I'm still curious about the annual weighted averages. Note that the annual weighted average is not the average of 12 monthly weighted averages. With annuals, you could plot just 13 annual averages over time.

The next stage would be to look at month/gen type values that are outliers, if there are any. I haven't spotted any yet.

Then after that, look at individual plants with coefficients unlike other plants with the same gen type. Weird plant, model glitch, or bad data?

Tim’s email from 8/11/2023

**A. Derived boiler efficiency trends graphed in file "boiler E trends 13y.xlsx"**

**A. Derived boiler efficiency trends graphed in file "boiler E trends 13y.xlsx"**

I reconstructed boiler efficiency for ST generation types based on TE and CD/MWh weighted monthly averages by generation type. The formula is in tab "by gen type", columns H, R, etc. I will scan my notes on this formula and attach them too.

These values of back-calculated average boiler efficiency change over the years with changes in the model and in reported boiler efficiency data.

Gen types gas^NGCC, oil^NGCC, other^NGCC, and nuke should have constant values, but move around slightly instead, probably due to accumulating error in calculations. These changes are inconsequential in terms of our results. There is no real "boiler efficiency" as such for these gen types, but the formula for boiler E returns a result that can be interpreted to detect errors.

Gen types biomass^ST, coal^ST, gas^ST, oil^ST, and other^ST have assumed values of boiler E through 2011. Then, as boiler E data becomes available in the 860 form, there are two years of abruptly higher efficiency in 2012-13. Finally, in 2014-2020, boiler efficiency decreases relative to 2013 by 0.1% (which is inconsequential) to as much as 3% for the small category of other^ST.

For the large categories coal^ST and gas^ST, did reporting of boiler efficiency change in 2014? Thermal efficiency did not change for these two categories in a way that would help explain the changes ini boiler efficiency.

For at least these two categories and other^ST, we should not plot a trend line for CD/MWh through years earlier than 2014 because the earlier changes in boiler efficiency are not real. They are a combination of model assumptions in the absence of boiler efficiecny data, and possble year to year differences in reporting.

I suggest that we publish coefficients based on 2014-2020 in the trends report. In the case of coal^ST, if the observed trend in TE is real, maybe we should just use the 2020 coefficients.

Future improvements could include an effort to correct 2012-13 boiler efficiencies and improve assumed boiler efficiencies in 2008-2011.

Future efforts to estimate thermoelectric water use in 2000-2007 should take into account the nature of boiler efficiency in the model. If we use coefficients to estimate these years, should we use 2008 coefficients or 2014 coefficients?

Notes on specific graphs:

biomass^ST ch

Assumed value of 78.16% through 2011, then bounces above that in 2012-13, then in range 78% - 78.16% 2014-20

coal^ST ch

Assumed value of 87.3804% through 2011, then around 88.7% in 2012-13, then in range 87% - 87.6% 2014-20

coal^ST TE ch

coal^ST thermal efficiency is maybe slightly lower ini 2012-13 but not enough to contribute to step change in CD/MWh

gas^NGCC ch

"Boiler E" trends from 80.00188% to 80.00197% over 13 years, rounding error? The ghost of efficiency increases? This was unexpected, it should be exactly 80%, but no harm done.

gas^ST ch

Assumed value of 86.135% through 2011, then around 87% to 88% in 2012-13, then in range 86% - 87% 2014-20

gas^ST TE ch

gas^ST thermal efficiency is not different from other years in 2012-13

nuke ch

"Boiler E" trends from 100.001354% to 100.00136% over 13 years, rounding error? This was unexpected, it should be exactly 100%, but no harm done.

oil^NGCC ch

"Boiler E" in range from 80.0014% to 80.0018% over 13 years, rounding error? This was unexpected, it should be exactly 80%, but no harm done.

oil^ST ch

Assumed value of 88.679% through 2011, then around 88.8% to 88.9% in 2012-13, then in range 89% - 89.6% 2014-20. Why so high, is it real?

other^NGCC ch

"Boiler E" in range just above 80% over 13 years, with odd jumps from 79.94 to 80.04 in 2010, and a few smaller excursions in later years. rounding error? This was unexpected, it should be exactly 80%, but no harm done.

other^ST ch

Assumed value of 87.2828% through 2011, then looks pretty normal with a 3% downward trend from 89% to 86%

**B. Calculating annual weighted averages.**

The monthly values are calculated by summing (for example) all the net gen for all lines of the right gen type in january, and dividing that sum times 3.412142 by the sum of all lines of fuel heat of the right gen type in January to get the weighted average thermal efficiency for January.

The annual values are calculated by summing (for example) all the net gen for all lines of the right gen type in all 12 months, and dividing that sum times 3.412142 by the sum of all lines of fuel heat of the right gen type in all 12 months to get the weighted average thermal efficiency for the year.

In file "compileCDintermediate2020\_THD\_work\_5b.xlsx" the annual weighted averages are calculated by this method in cells KX14-KY14