Comments on
Load Forecast Model Development

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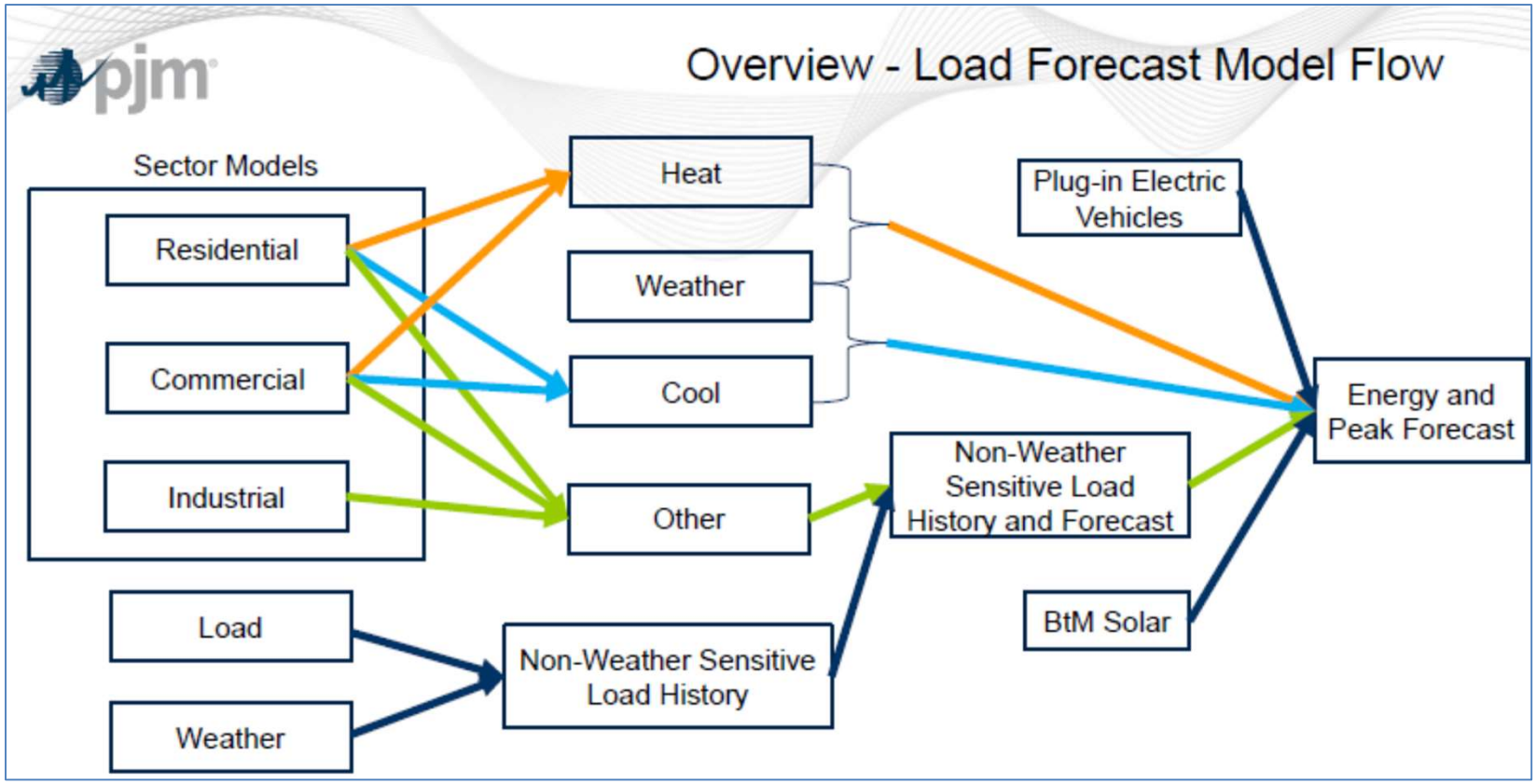
PJM Load Analysis Subcommittee
October 22, 2020

Scope of Presentation

1. Concerns about new (2019-2020) load forecasting methodology
   A. Main cause of concern: forecasts in some zones inconsistent with recent trends
   B. Drill down to identify a main source: Other End-Use index, industrial models
   C. Comments on PJM's presentation and two key sensitivity analyses
   D. Suggestions re: potential fixes (focus on 2021 forecast now under development)
2. Comments on approaches to COVID (very brief)

The graphs shown in this presentation are based on the files posted for the September LAS meeting (April 2020 economics). Graphs are 2020 = 1.0, to better illustrate the trends in history and forecast. Not all zones are shown, mainly to keep the slides less busy.

The New Load Forecast Methodology



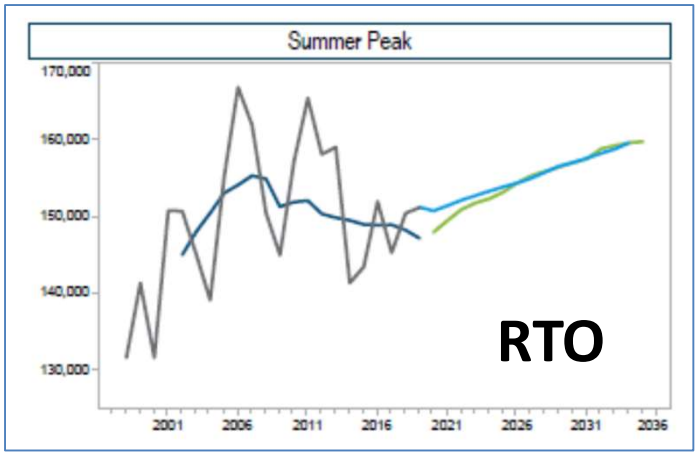
PJM, *Load Forecast Model Development*, September 21, 2020 LAS slide 4.

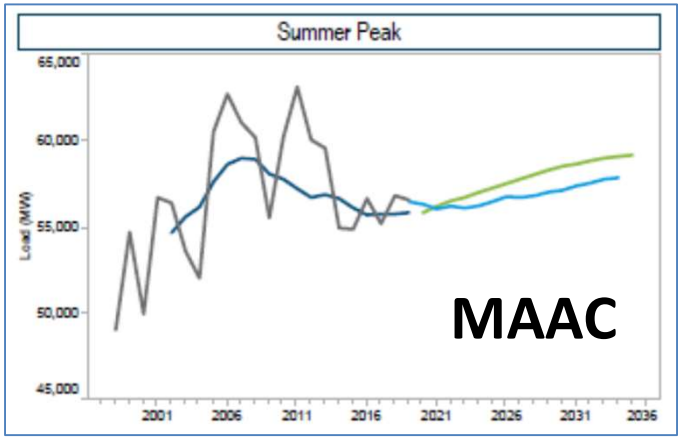
New Methodology: Preliminary Observations

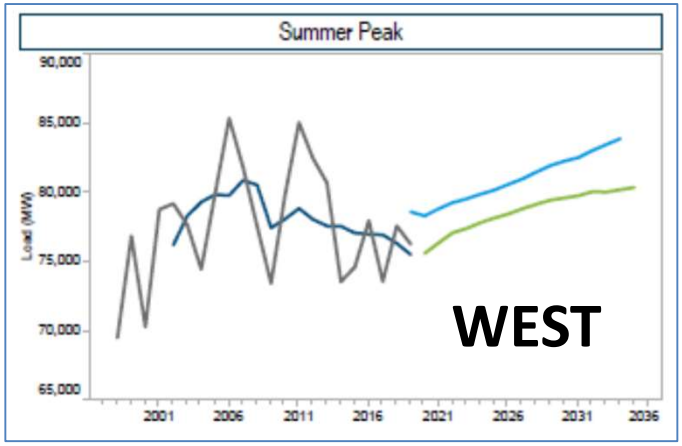
- Much more complex - now three+ stages
  - The new, first stage – Sector Models – is multi-part, complex (PJM slides 6-34)
- Documentation is not comprehensive (especially the sector models)
- The complexity affords substantial scope for variations and tweaks (as reflected in changes from August 2019 to September to December); details are not fully documented or transparent
- Supporting data to forecast is much less complete than in past years

Previously, the zonal forecasts could be closely approximated from load history and the posted economic/demographic and efficiency drivers (based on exogenous forecasts from Moody's, Itron). Not any more.

2020 Forecasts Rise Despite 10+ Years of Declining WN Peaks

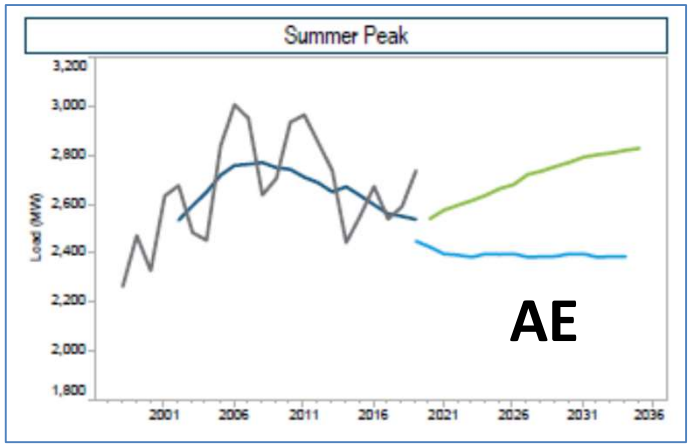


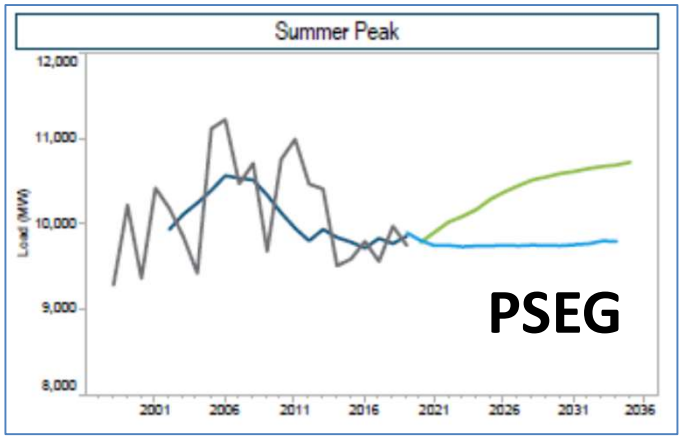


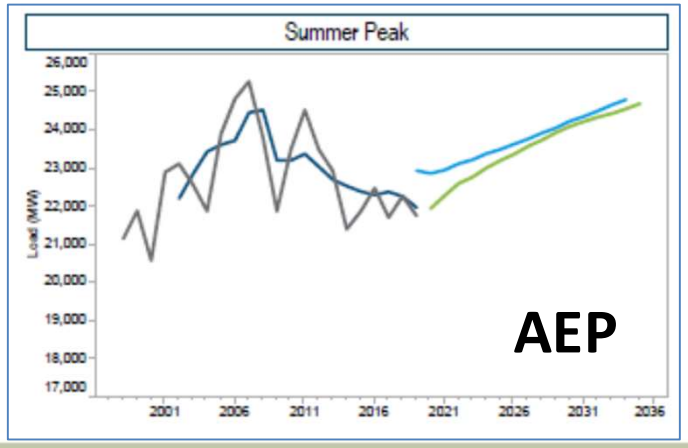


Source: PJM 2020 Load Forecast Report

2020 Forecasts Rise Despite 10+ Years of Declining WN Peaks







Peak WN peak Forecast 2019 Forecast 2020

Source: PJM 2020 Load Forecast Report

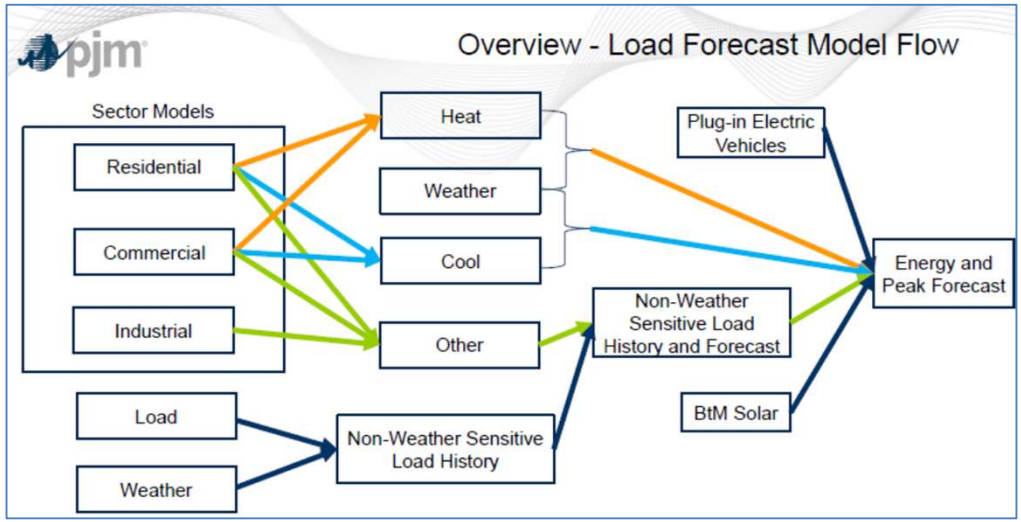
Several, but not all, zones have forecasts that deviate sharply from trend in summer and/or winter peak forecasts.

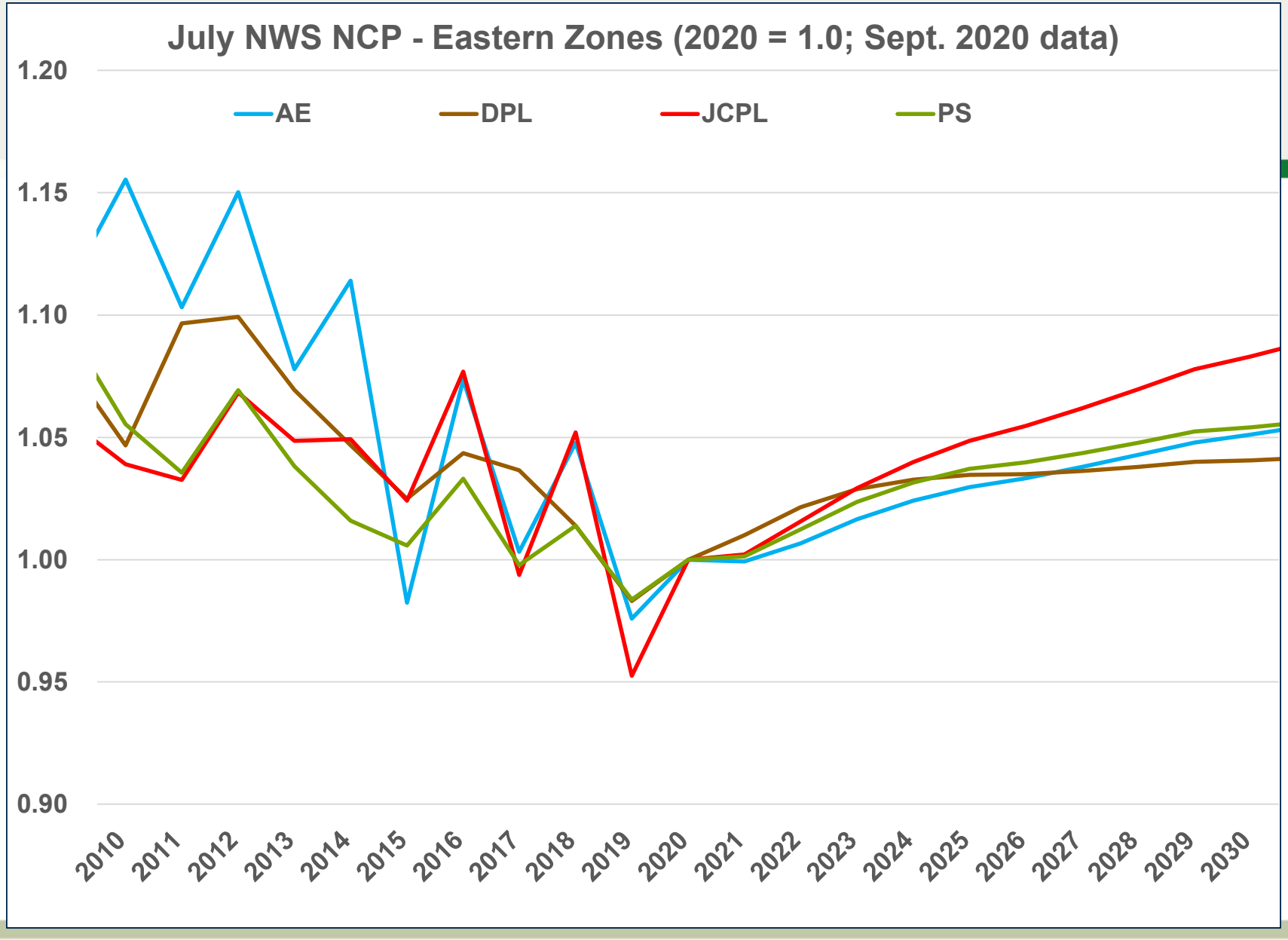
What Is Driving the Forecasts to Break from Trend?

Q1: Non Weather Sensitive (NWS) or WS Loads? (A: mainly NWS)

Q2: What Drives NWS Higher? (A: mainly Other End-Use Index)

The next several slides show history and forecast of NWS and Other End-Use Index, from LAS Sept. 21 materials, on a 2020 = 1.0 basis.




July NWS NCP - Eastern Zones (2020 = 1.0; Sept. 2020 data)
AE
DPL
JCPL
PS
1.20
1.15
1.10
1.05
1.00
0.95
0.90
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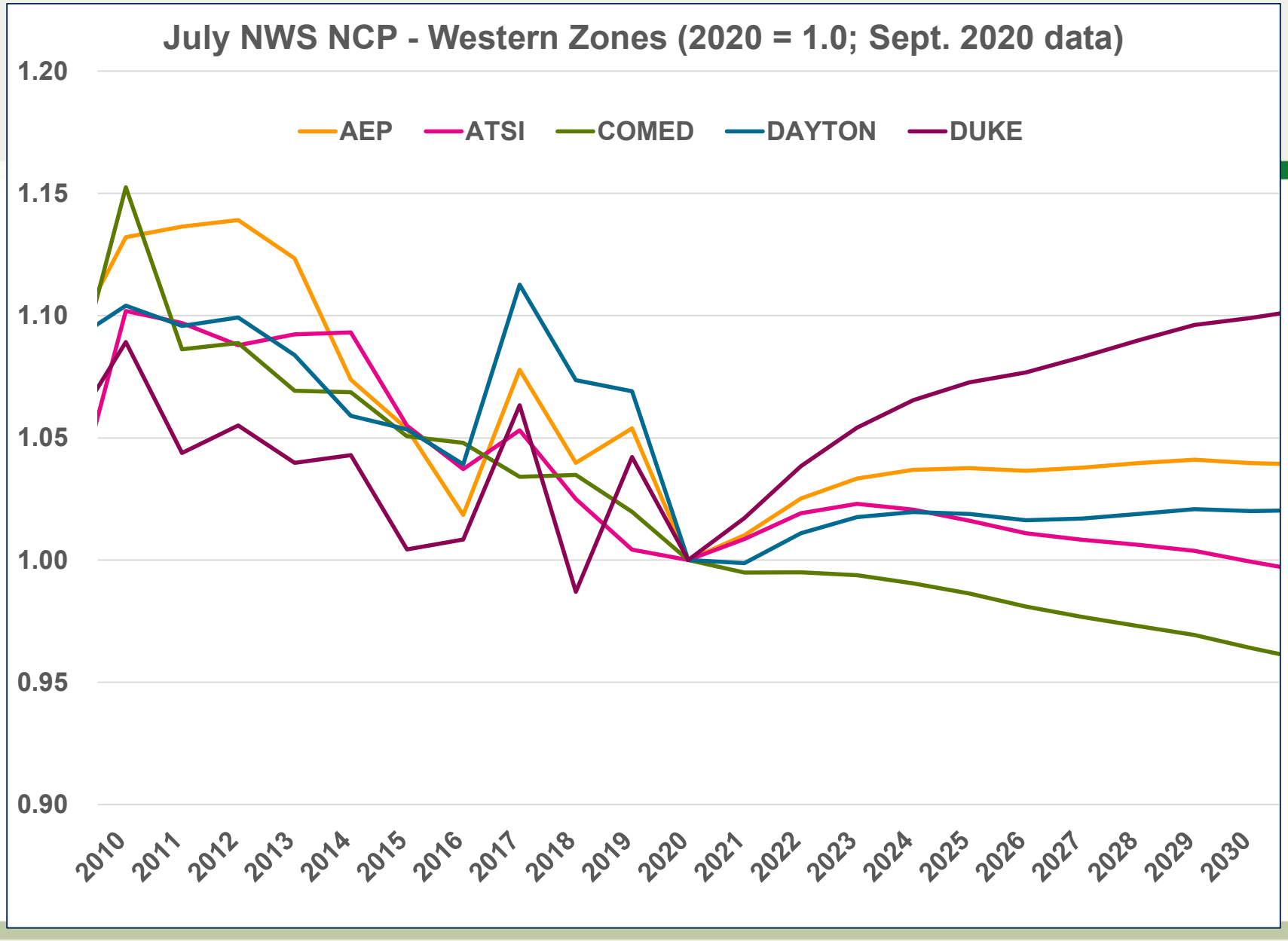
July NWS NCP - Western Zones (2020 = 1.0; Sept. 2020 data)
1.20
1.15
1.10
1.05
1.00
0.95
0.90
AEP
ATSI
COMED
DAYTON
DUKE
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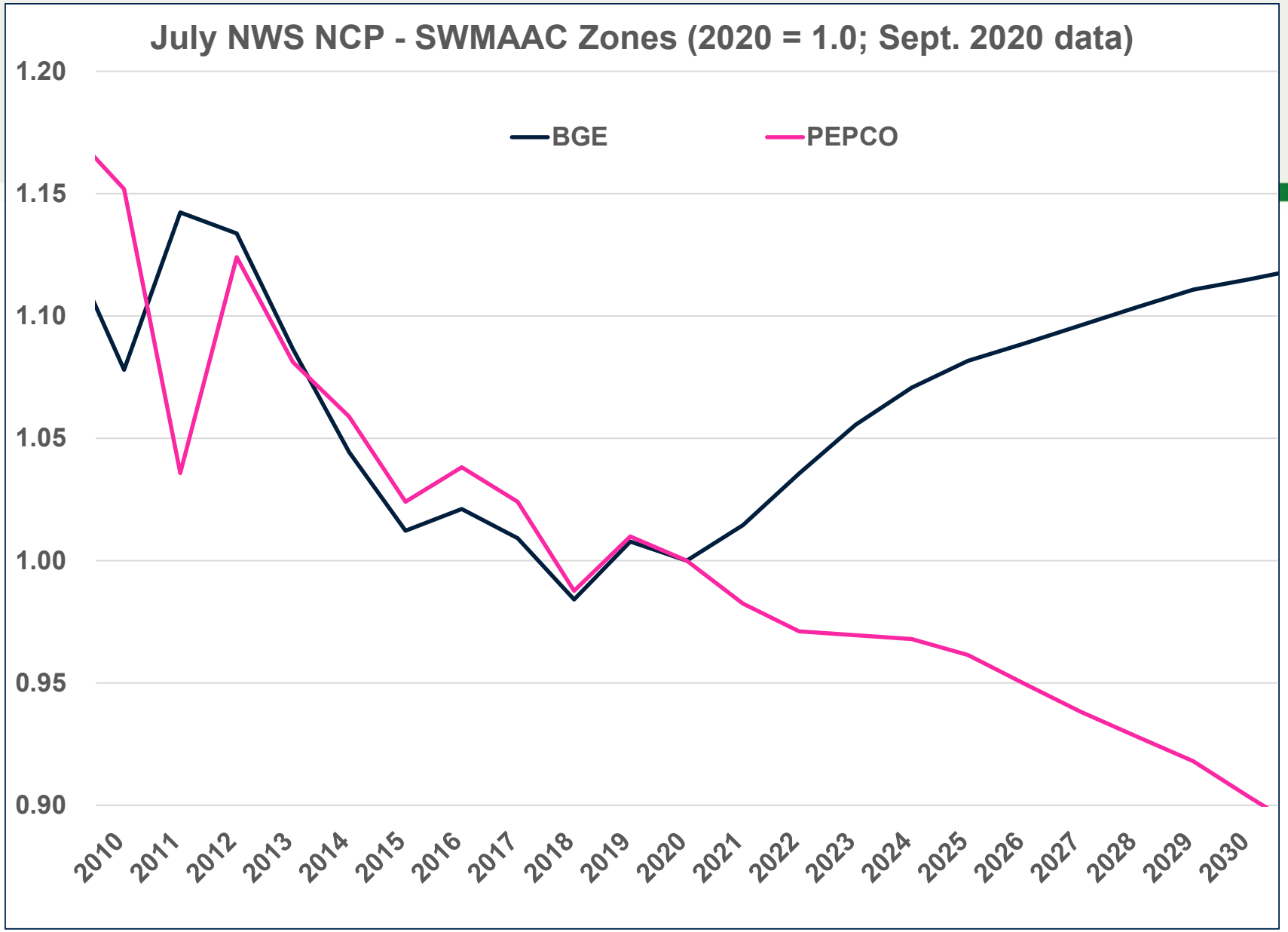
July NWS NCP - SWMAAC Zones (2020 = 1.0; Sept. 2020 data)
1.20
1.15
1.10
1.05
1.00
0.95
0.90
BGE
PEPCO
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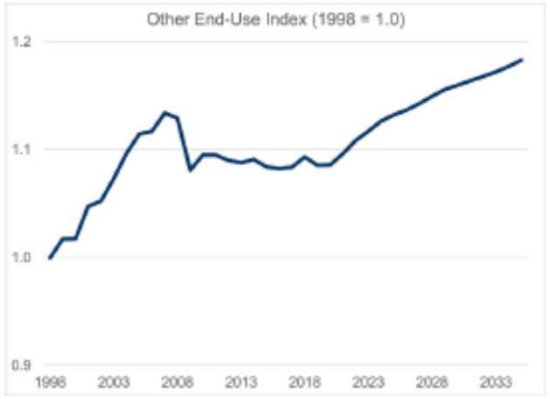
Focus on Other End-Use Index

PJM 2020 *Load Forecast Supplement*, page 14:

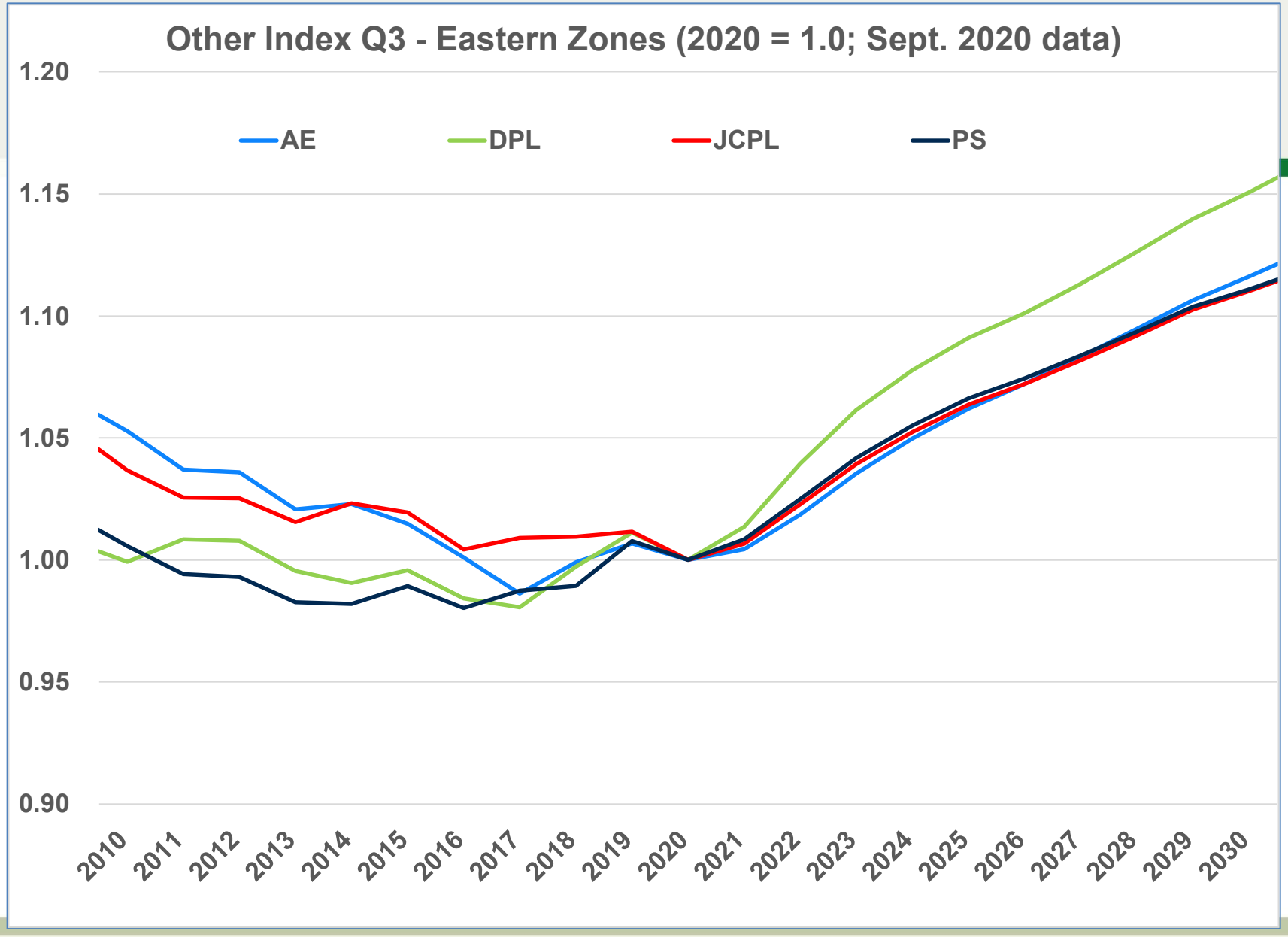
Other

The Other End-Use Index has a forecasted average annual growth rate of 0.6% from 2020-2035, up slightly from a 0.4% average annual growth rate from 1998-2018.



The rate of growth of the Other End-Use Index was 1.8%/year during the six years from 1998 to 2004, and the index fell over the fifteen years since.

PJM uses a 10-year estimation period for the main forecast models, while the Other End-Use, Cooling and Heating indexes are calibrated using data from 1998 (22 years). *PJM's sensitivity analysis to this assumption is discussed later in the presentation.*


Other Index Q3 - Eastern Zones (2020 = 1.0; Sept. 2020 data)
1.20
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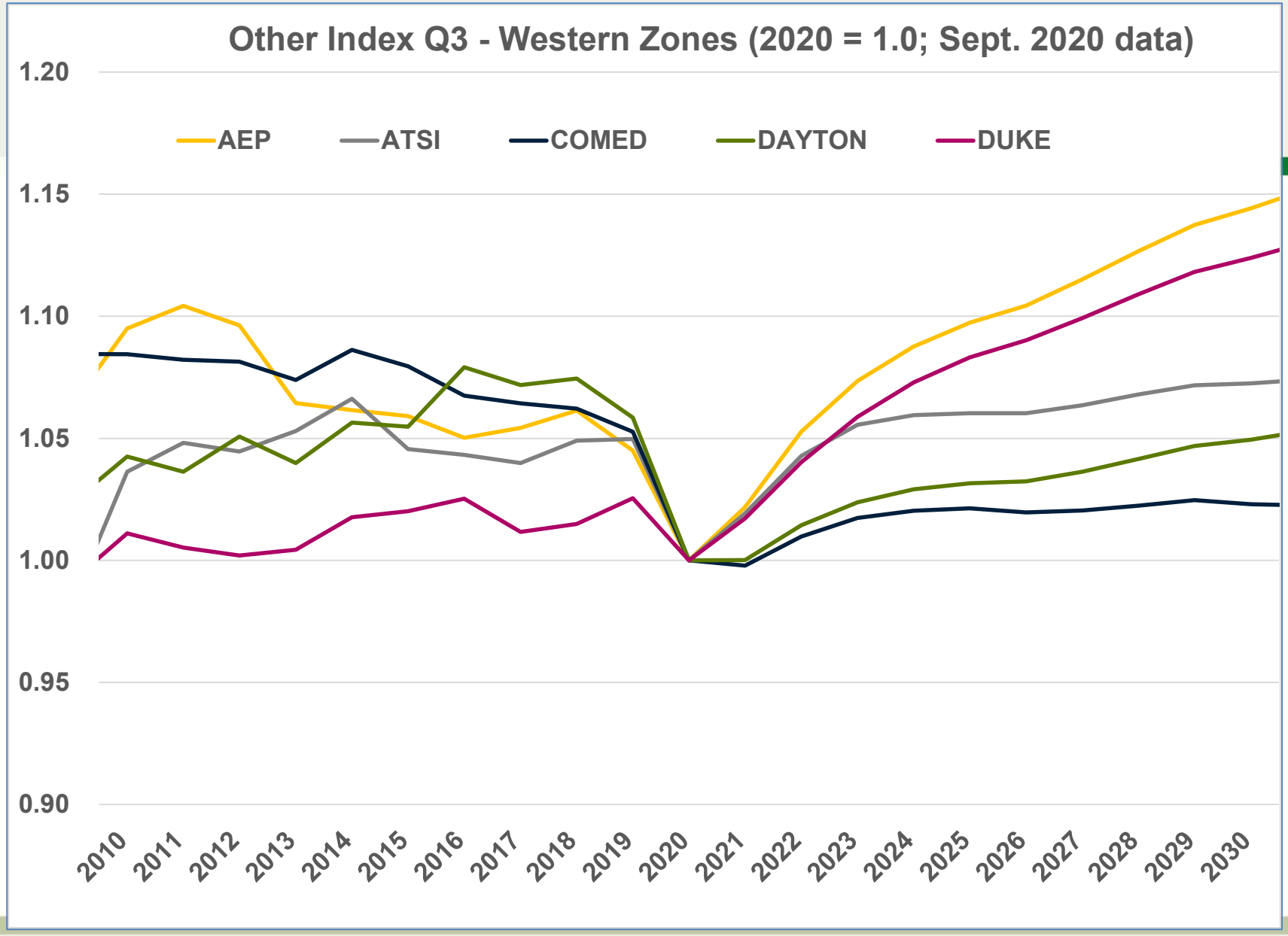
Other Index Q3 - Western Zones (2020 = 1.0; Sept. 2020 data)
1.20
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1.10
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0.90
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DAYTON
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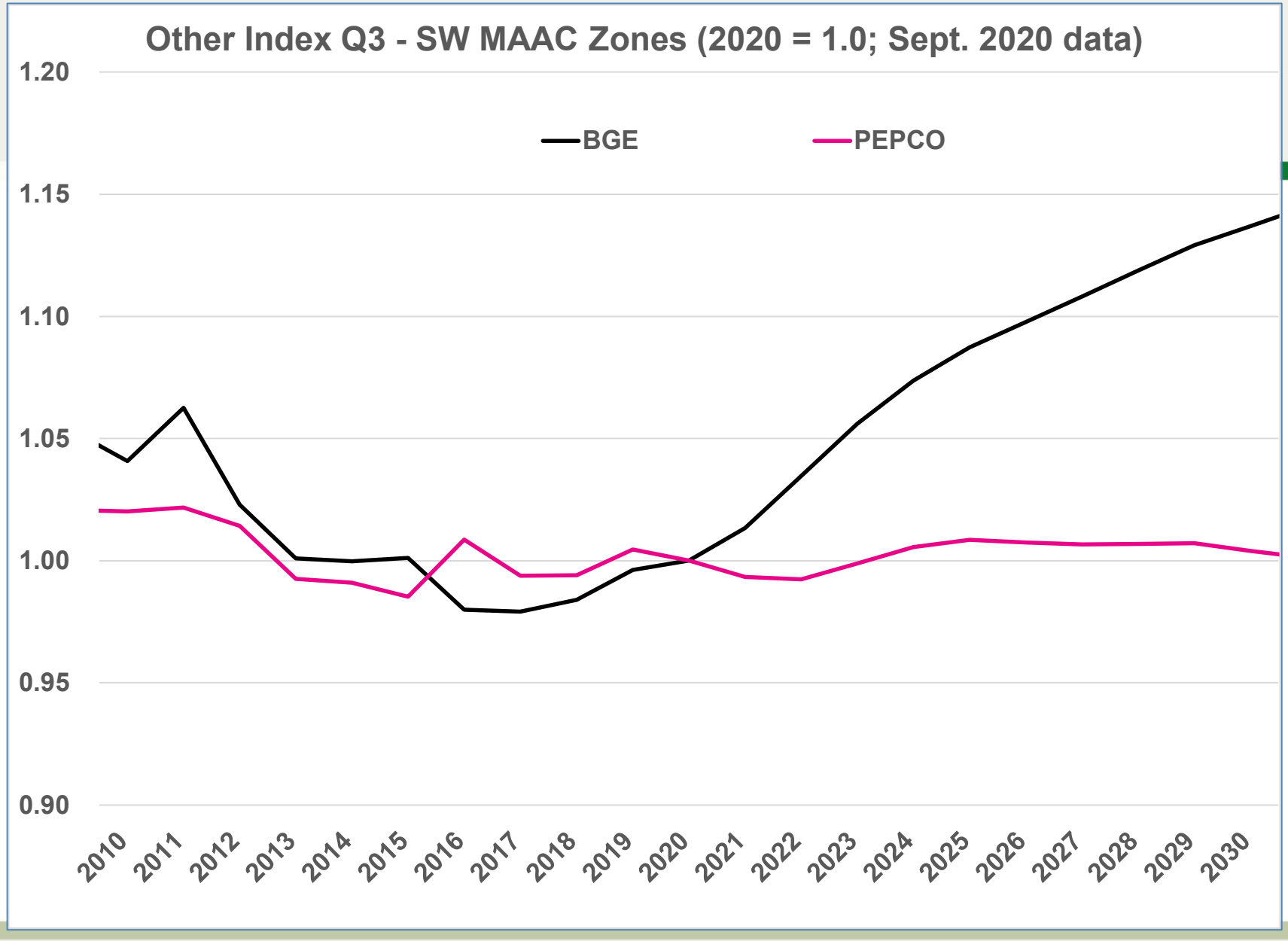
Other Index Q3 - SW MAAC Zones (2020 = 1.0; Sept. 2020 data)
1.20
1.15
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0.95
0.90
BGE
PEPCO
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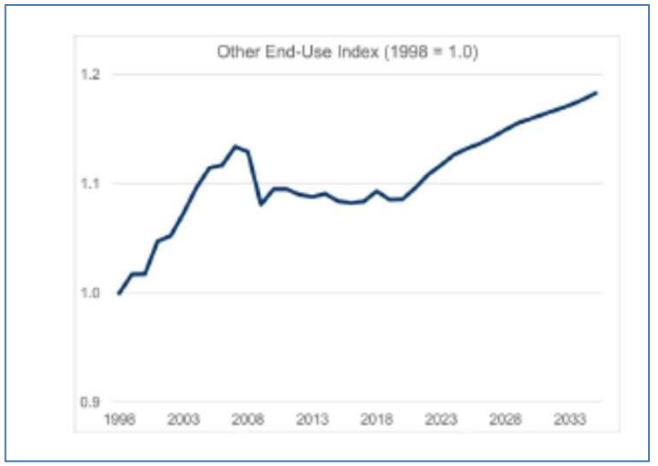
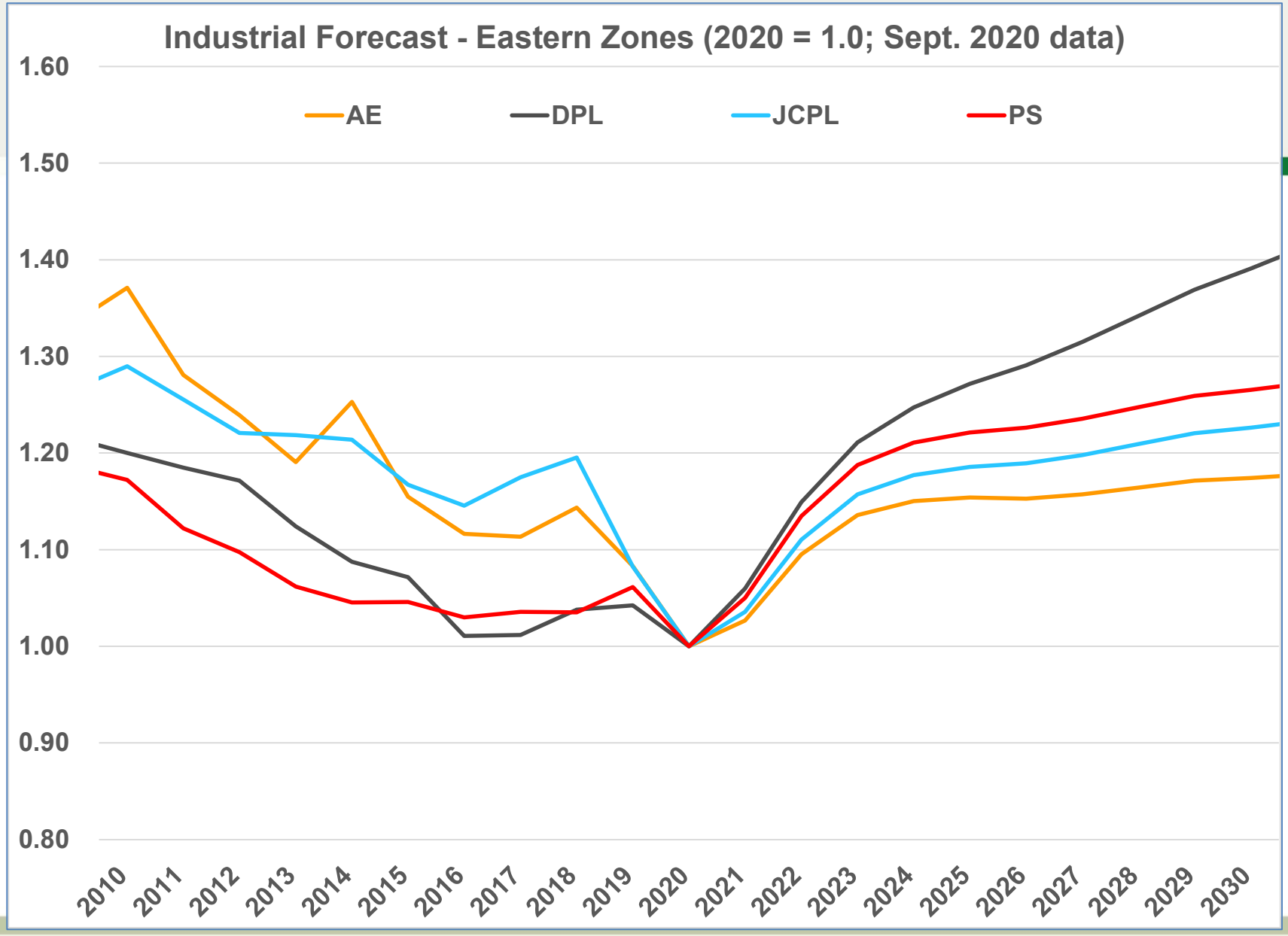
What Is Driving the Other End-Use Index Upward Despite the Long History of Decline?

1. The main issue is apparently the 22-year estimation period for the sector models that feed into the Other End-Use Index.
2. The industrial sector models appear to be the main drivers.
   - The Residential and Commercial sectors typically have smoother and more continuous shape.




Industrial Forecast - Eastern Zones (2020 = 1.0; Sept. 2020 data)
AE
DPL
JCPL
PS
1.60
1.50
1.40
1.30
1.20
1.10
1.00
0.90
0.80
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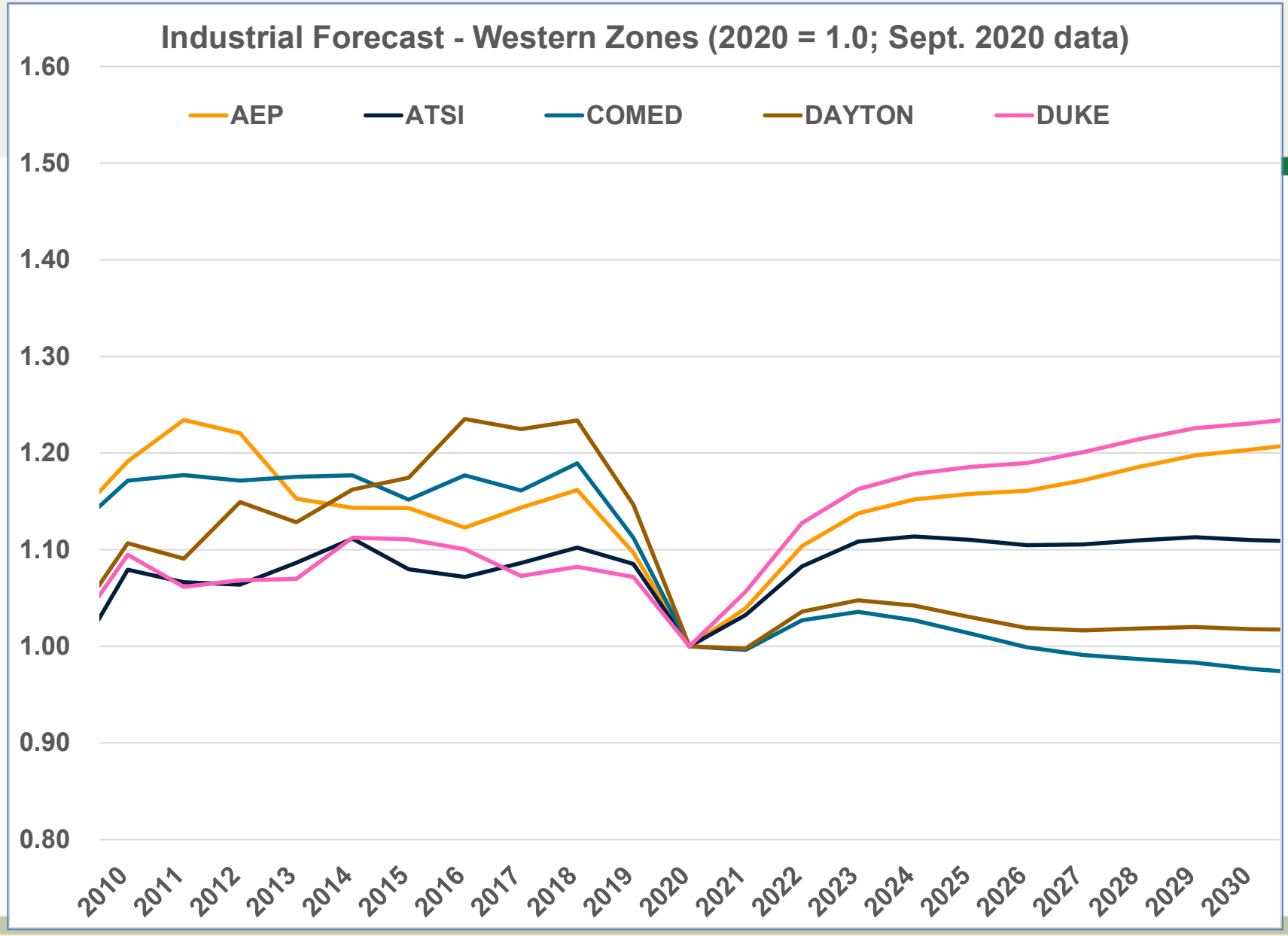
Industrial Forecast - Western Zones (2020 = 1.0; Sept. 2020 data)
AEP
ATSI
COMED
DAYTON
DUKE
1.60
1.50
1.40
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1.20
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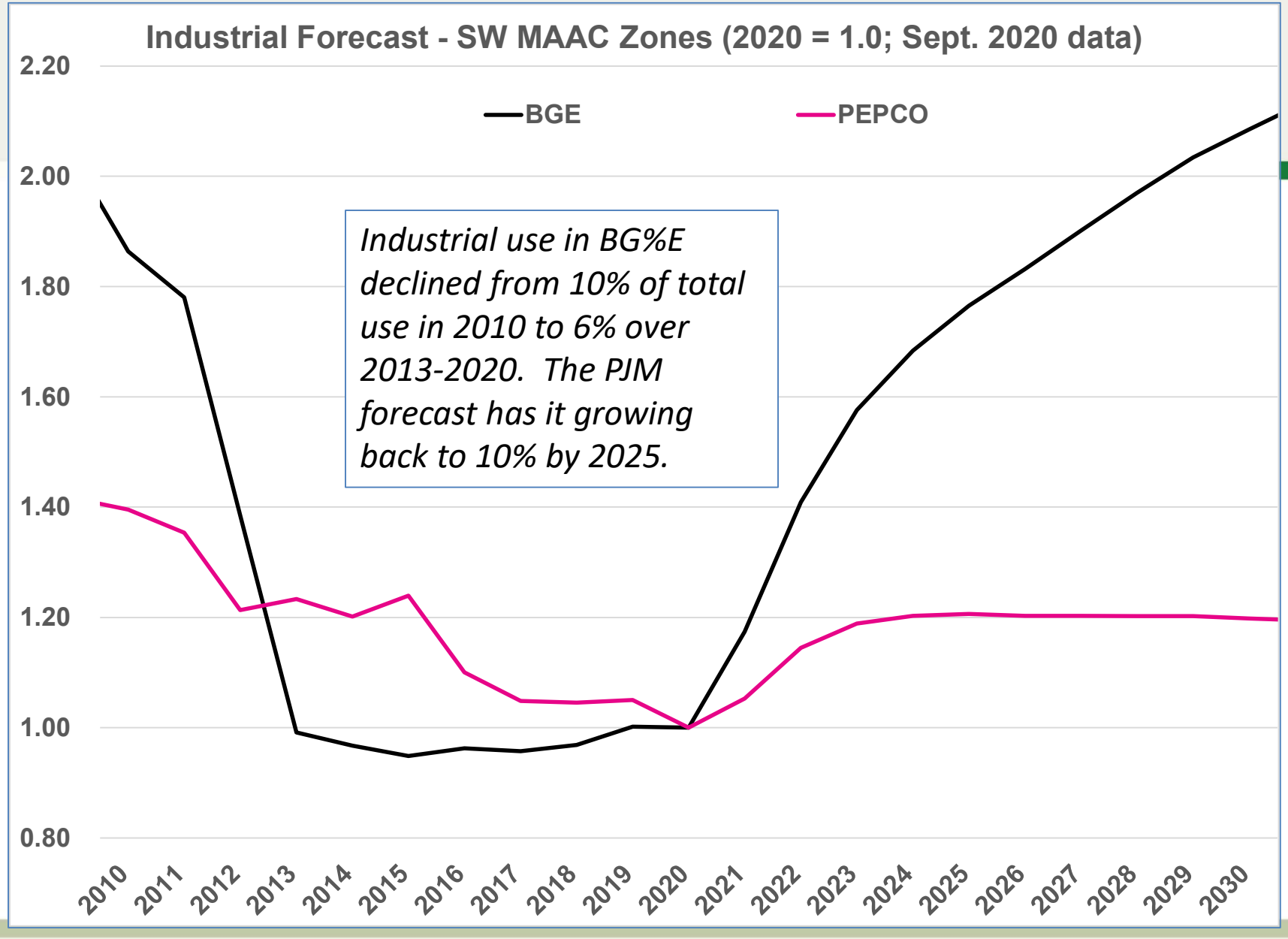
Industrial Forecast - SW MAAC Zones (2020 = 1.0; Sept. 2020 data)
BGE
PEPCO
2.20
2.00
1.80
1.60
1.40
1.20
1.00
0.80
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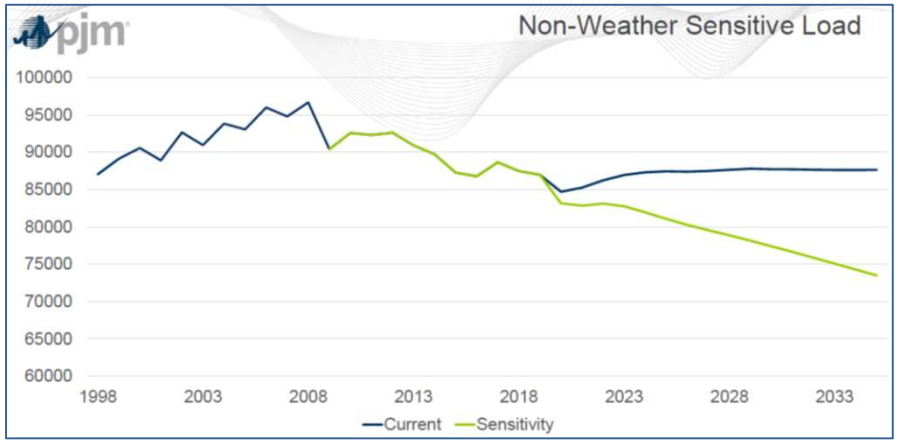
Industrial use in BG%E declined from 10% of total use in 2010 to 6% over 2013-2020. The PJM forecast has it growing back to 10% by 2025.

Consistent 10-Year Estimation Period Sensitivity

- Under the new load forecasting methodology, PJM uses a 10-year estimation period. However, to date an exception was made for the sector models, where 22 years have been used.

- PJM ran a sensitivity analysis which applied a consistent 10-year estimation period for all modeling (slides 89-99). This has a large impact on the forecast, and brings the NWS forecast in line with the trend since about 2005.



Consistent 10-Year Estimation Period Improves the Forecast but Reveals a Commercial Model Flaw

- PJM objects to use of the consistent 10-year estimation period because in some zones it results in Commercial Model coefficients having unexpected sign (slide 96). Details were not provided.
- This symptom suggests a missing explanatory variable in the Commercial Model. 2009-2019 was a relatively stable period; it should not be difficult t specify a model that can make sense of commercial load trends during this period.
- Simply adding older data (1998-2008) is not a solution.
  - Adding data for 1998-2008, when quite different and more complex relationships were in play (strong growth in 1998-2004, recession in 2008-2009) in principle should require a more complex model with more variables.
  - Simply using more data in the same model may hide the symptom but does not address the flaw.

Industrial Sector Models

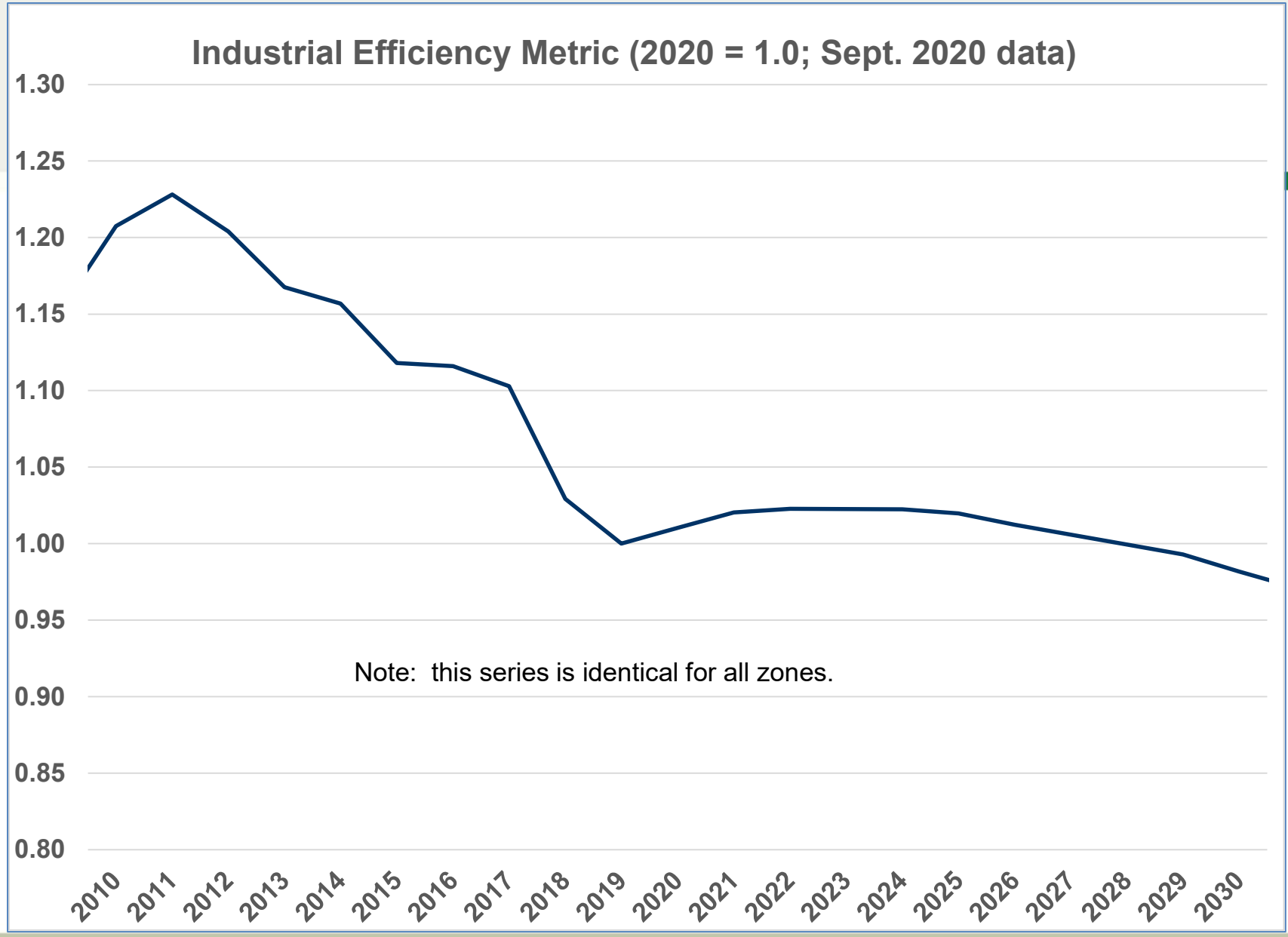
- Per PJM presentation (slides 30-33) and September LAS files, the Industrial model is Real Goods Output (fgood) x
  Electricity per Real Output (aka Industrial Efficiency Metric)
- Fgood – fairly steady in history and forecast (Sept. files)
- Industrial Efficiency Metric: exhibits the down-then-up shape.

Industrial Efficiency Metric

- A single metric for all industrial load. It must represent both shifts in industrial subsector output and changes in efficiency.
- This metric is built on national data.
- This metric is a hybrid, using different data sources for the history and the forecast (per Supplement and email from PJM):
  - History portion: EIA U.S. Industrial Sales from EIA 861 *divided by* Moody's forecast of real goods-producing output
  - Forecast portion: EIA Annual Energy Outlook 2019 reference case projection of Purchased Electricity per Dollar of Industrial Output

EIA 861 data: https://www.eia.gov/electricity/data/state/sales_annual.xlsx

EIA AEO data: https://www.eia.gov/outlooks/aeo/data/browser/#/?id=6-AEO2019&cases=ref2019


Industrial Efficiency Metric (2020 = 1.0; Sept. 2020 data)
1.30
1.25
1.20
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
Note: this series is identical for all zones.
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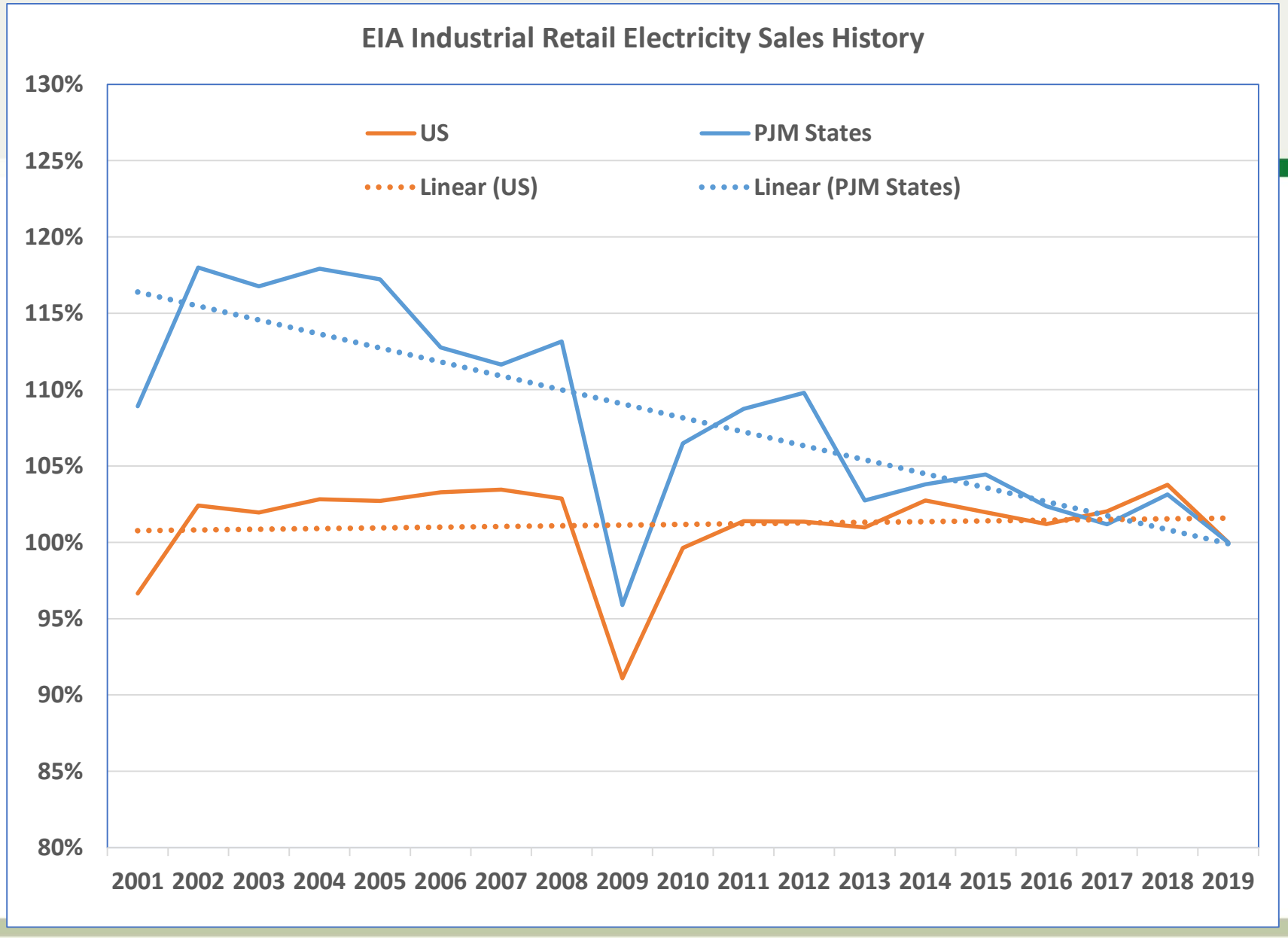
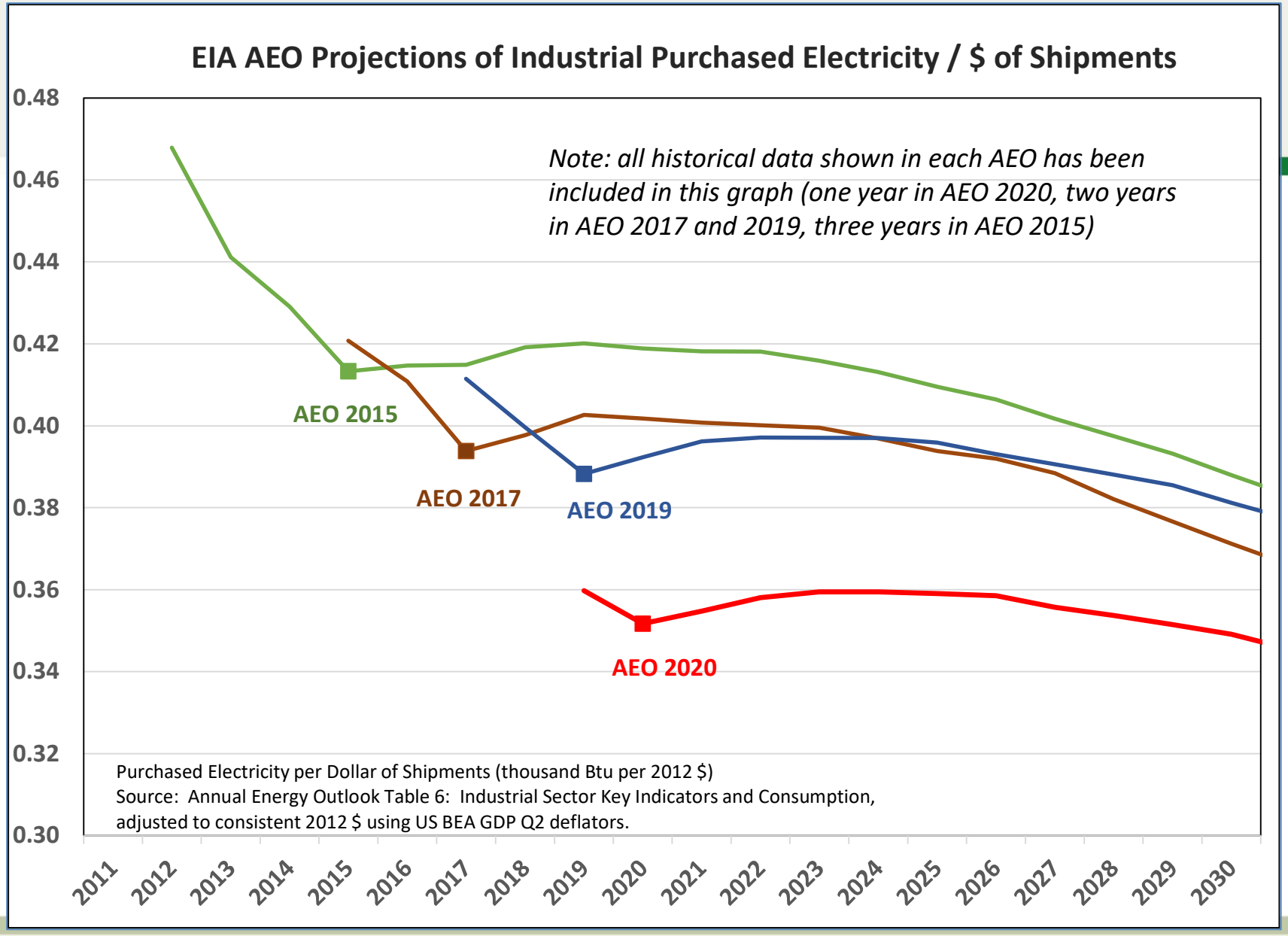
Industrial Efficiency Metric: Concerns

1. Hybrid metric (different source for history and projection) does not assure consistency between history and forecast.
2. Uses national data: but industrial trends are different in PJM region (next slide).
3. The AEO projections of industrial electricity per dollar of shipments have the same troubling shape of recent declines but sharp increase going forward; and have had this shape since AEO 2015 (following slide).

Also, note that EIA emphasizes that the AEO values are projections not predictions or forecasts: "The value of the projections in the AEO2020 is not that they are predictions of what will happen, but rather, they are modeled projections of what may happen given certain assumptions and methodologies…" AEO 2020 p. 3.


EIA Industrial Retail Electricity Sales History
130%
125%
120%
115%
110%
105%
100%
95%
90%
85%
80%
US
PJM States
Linear (US)
Linear (PJM States)
2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019


EIA AEO Projections of Industrial Purchased Electricity / $ of Shipments
0.48
0.46
0.44
0.42
0.40
0.38
0.36
0.34
0.32
0.30
Note: all historical data shown in each AEO has been included in this graph (one year in AEO 2020, two years in AEO 2017 and 2019, three years in AEO 2015)
AEO 2015
AEO 2017
AEO 2019
AEO 2020
Purchased Electricity per Dollar of Shipments (thousand Btu per 2012 $)
Source: Annual Energy Outlook Table 6: Industrial Sector Key Indicators and Consumption, adjusted to consistent 2012 $ using US BEA GDP Q2 deflators.
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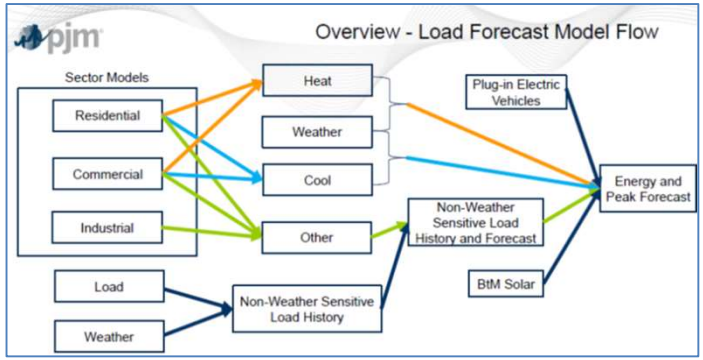
The Industrial Efficiency Metric Has Large Impact

- PJM's sensitivity analysis shows that replacing this national metric with a simple extrapolation of history has a large impact on the industrial forecasts (PJM presentation slides 84-86). While the extrapolated series is not proposed as an alternative, its use in the sensitivity analysis reveals that this metric has a large impact.
- The Industrial Efficiency Metric drives the industrial sector forecasts, and this flows through to the Other End-Use Index and NWS forecast (details have been requested).



Load Forecast Model Development – Conclusions

1. A consistent historical estimation period (10 years) should be used throughout the modeling. The Commercial Sector Model should be corrected (e.g. add an explanatory variable) as necessary.
2. The current construction of the Industrial Efficiency Metric, using a hybrid approach based on national data, should be improved. Possible directions:
    1. Use regional data.
    2. Perhaps subdivide the industrial sector (e.g., heavy and light industry).
    3. Other approaches.

Comment on Approach to COVID-Affected Loads

- The foregoing is about the methodology as developed over 2018-2019; that discussion does not have to do with pandemic impacts.
- 2020 load data reflects impacts of shutdowns, working at home, and other complex and transitory impacts that are peculiar to 2020. The simplest and most straightforward approach to long-term forecasting is to ***not use*** 2020 load data that reflects these ephemeral impacts.
- Any approach that tries to use 2020 load data will implicitly make assumptions about the extent to which things return to normal
  - How many workers return to offices, how many continue to work at home
  - Reductions in office space, to extent working at home continues
  - Improvements to residential A/C and EE after high 2020 loads and bills, etc.