

GREENHOUSE GASSES FROM POWER SECTOR

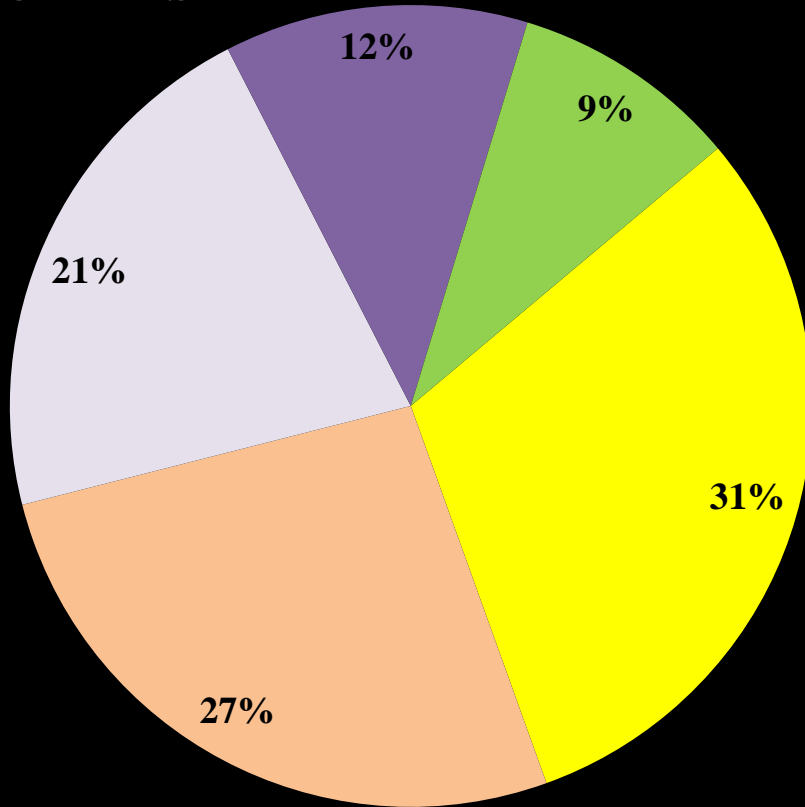
KEYS TO IMPROVE ESTIMATION

Kotur S. Narasimhan



TYPICAL SOURCE SHARE OF GREENHOUSE GASSES

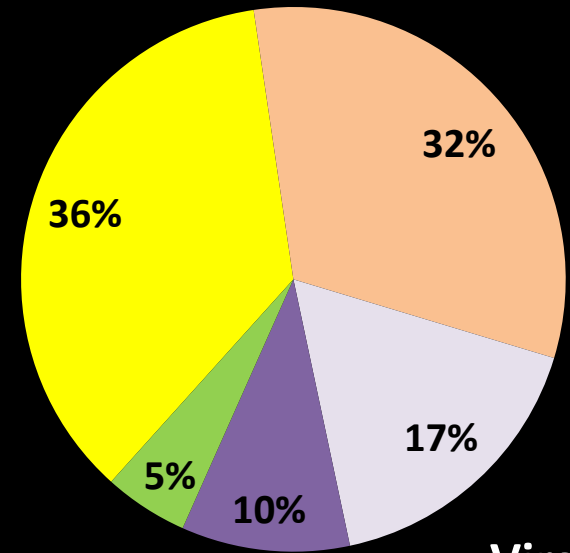
United States



6,740 MMT CO₂ (2015)

- Electricity
- Transportation
- Industry
- Commercial & Residential
- Agriculture

198 MMT CO₂ (2015)



Virginia

GHG INVENTORY SOURCES

- NATIONAL LEVEL – EPA ANNUAL REPORTS
- STATE LEVEL –

→ **STATE INVENTORY TOOL (SIT)**

INDIVIDUAL STATE DEPARTMENTS

**GREENHOUSE GAS REPORTING
PROGRAM (GHRP) – Major Sources**

SIT also provides an alternate method to
estimate GHG based on **POWER USAGE**

GHG EMISSIONS FROM POWER GENERATION & USAGE

- **CARBON DIOXIDE [CO₂]**
- **METHANE [CH₄]**
- **NITROUS OXIDE [N₂O]**

- **METHANE [CH₄]**
- **NITROUS OXIDE [N₂O]**

- **SULFUR HEXAFLUORIDE [SF₆]**

- **ALL THE ABOVE**

**FROM COMBUSTION OF
FOSSIL FUELS**

WASTES & BIOMASS

**TRANSMISSION &
DISTRIBUTION
EQUIPMENT**

**POWER USED BUT NOT
GENERATED**

DATA SOURCES

FOR POWER SECTOR GHG ESTIMATION OF CO₂, CH₄ & N₂O EMISSIONS

ENERGY INFORMATION ADMINISTRATION
[EIA]

STATE ENERGY DATA
SYSTEM [SEDS]



STATE INVENTORY
TOOL [SIT]
STATE LEVEL COMPOSITE
DATA

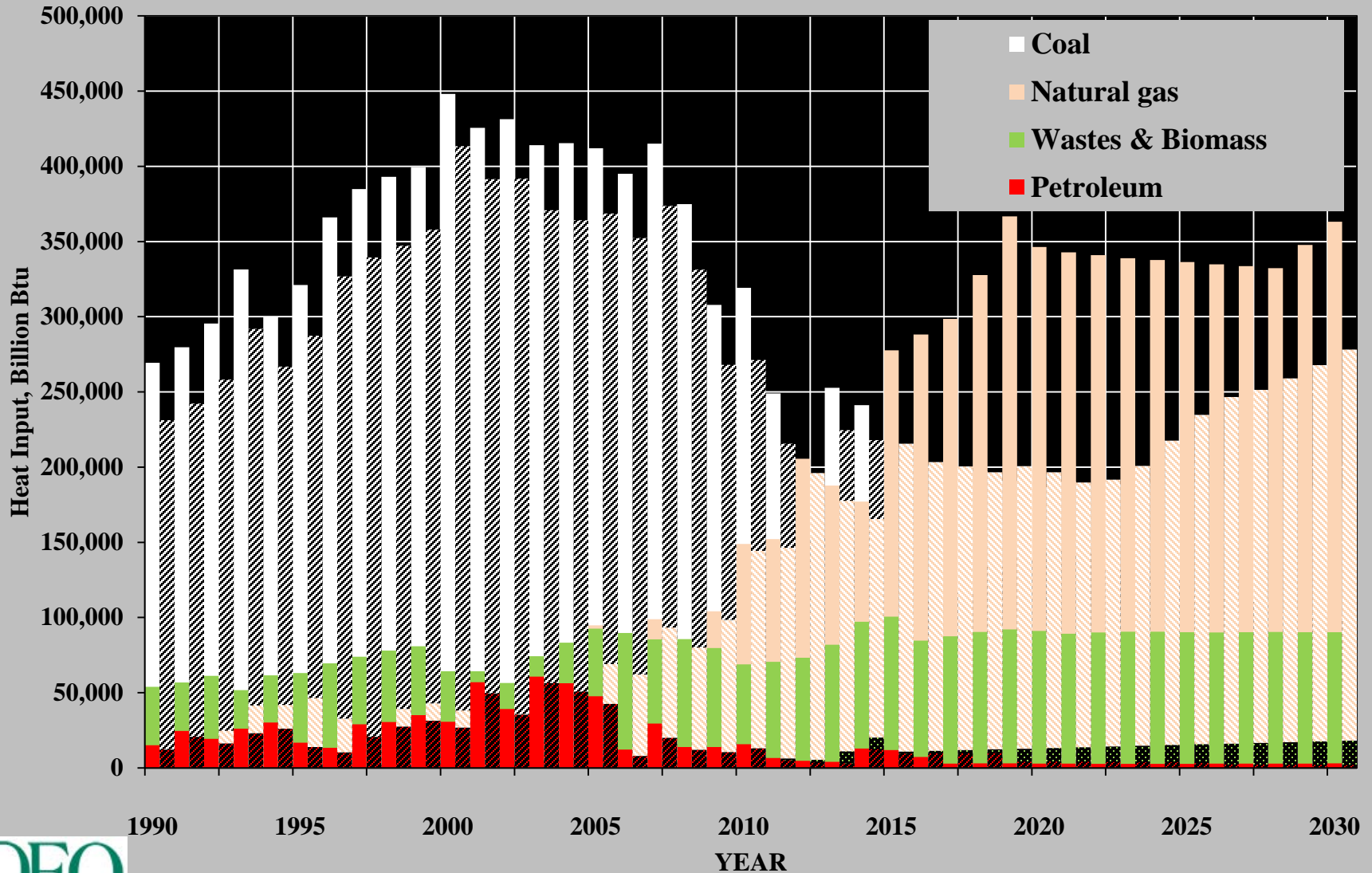
ELECTRICITY SECTION
EIA-906/920/926
INDIVIDUAL SOURCES
MANDATORY
REPORTING
ALSO
STATE PROFILES

FUEL TYPE UNIT LEVEL DATA

COMPARISON OF HEAT INPUT DATA

SOLID COLORS: EIA-906

PATTERN: SEDS DATA



DATA SOURCES

FOR POWER SECTOR GHG ESTIMATION OF SF₆ EMISSIONS

STATE INVENTORY TOOL DOES NOT INCLUDE SF₆ EMISSIONS IN POWER SECTOR BUT CONSIDERS AS PART OF **INDUSTRIAL PROCESSES** EITHER BASED ON PURCHASE OR ON NATIONAL SALE PRORATED TO ELECTRICITY SOLD IN THE STATE

IN THE PRESENT COMPUTATION SF₆ EMISSIONS IS BASED ON THE DOMINION POWER'S GHGRP REPORTS FOR 2011-2015

| YEAR | Power Sold | Reported SF ₆ |
|------|-------------|--------------------------|
| | Million KWh | MT CO ₂ E |
| 2011 | 74,324 | 116,873 |
| 2012 | 72,604 | 47,759 |
| 2013 | 74,469 | 46,446 |
| 2014 | 75,563 | 75,671 |
| 2015 | 76,025 | 53,819 |

POWER SECTOR GHG EMISSIONS ESTIMATION STRATEGY

- TAKE INTO ACCOUNT ALL ENERGY CONSUMED IN PAST /LIKELY IN FUTURE FOR POWER GENERATION;
- ESTIMATE ALL POWER GENERATED / LIKELY TO BE GENERATED IN THE STATE;
- ESTIMATE ADDITIONAL POWER BY IMPORTS BASED ON TOTAL SALE / DEMAND;
- ESTIMATE CO₂, CH₄, & N₂O BASED ON GENERATION & SF₆ EMISSIONS BASED ON TOTAL CONSUMPTION;
- ESTIMATE CORRESPONDING EMISSIONS FOR IMPORTED POWER PRORATED TO GENERATION;

PROJECTING FUTURE GENERATION & DEMAND

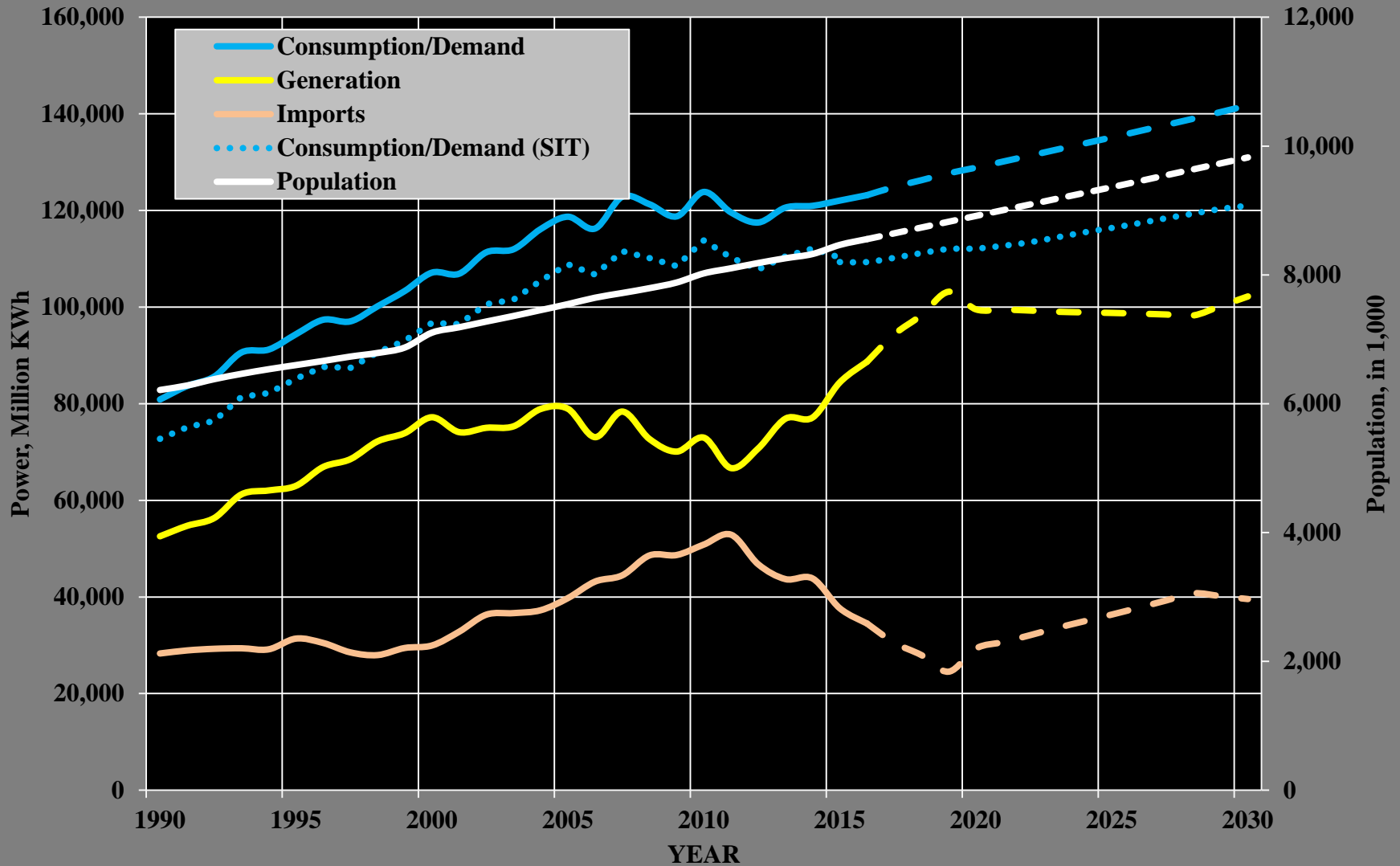
PROJECTION TOOL IN SIT IS BASED ON ANNUAL ENERGY OUTLOOK (AEO) OF EIA; LATEST SIT IS BASED ON AEO 2014

CURRENT ASSESSMENT ALSO INCLUDES AEO 2015 & OUTPUT FROM THE TOOL OF EASTERN REGIONAL TECHNICAL ADVISORY COMMITTEE (ERTAC) FOR MAJOR FOSSIL FUEL UNITS

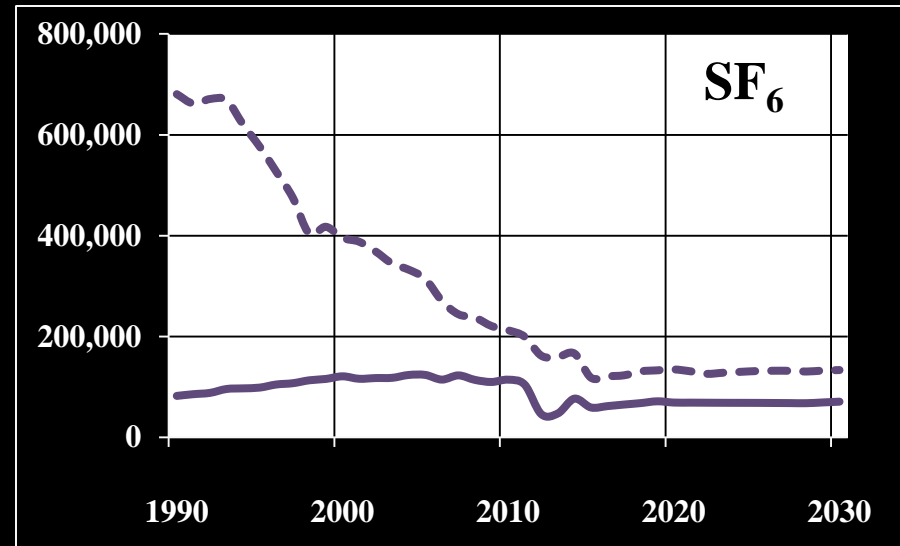
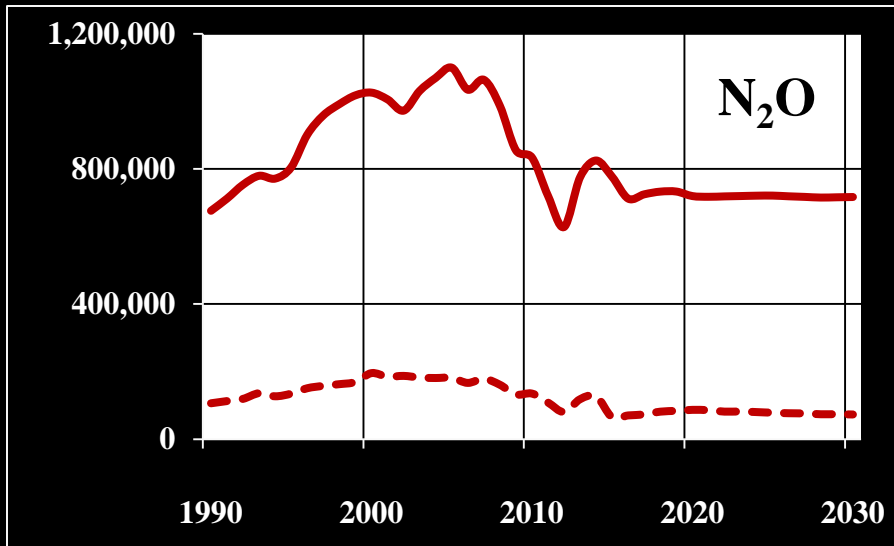
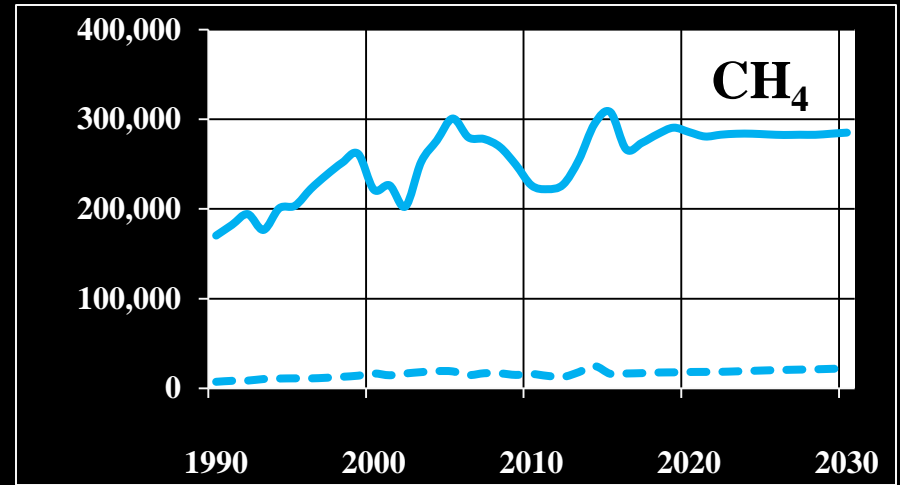
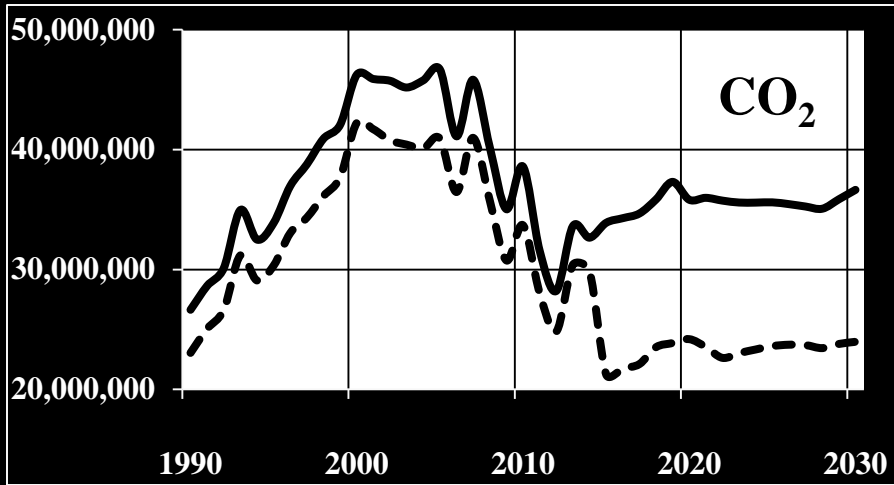
*Based on replication of hourly performance of electric grid with reference to a base year subject to availability of old/new units and fuel type;
For units not covered by ERTAC five year running average values are used*

DEMAND FOR POWER & RESULTING IMPORTS NEED IS ARRIVED AT TO MAINTAIN CURRENT (2015) PERCAPITA ADJUSTED TO GROWTH IN POPULATION

POWER GENERATION & DEMAND SCENARIO

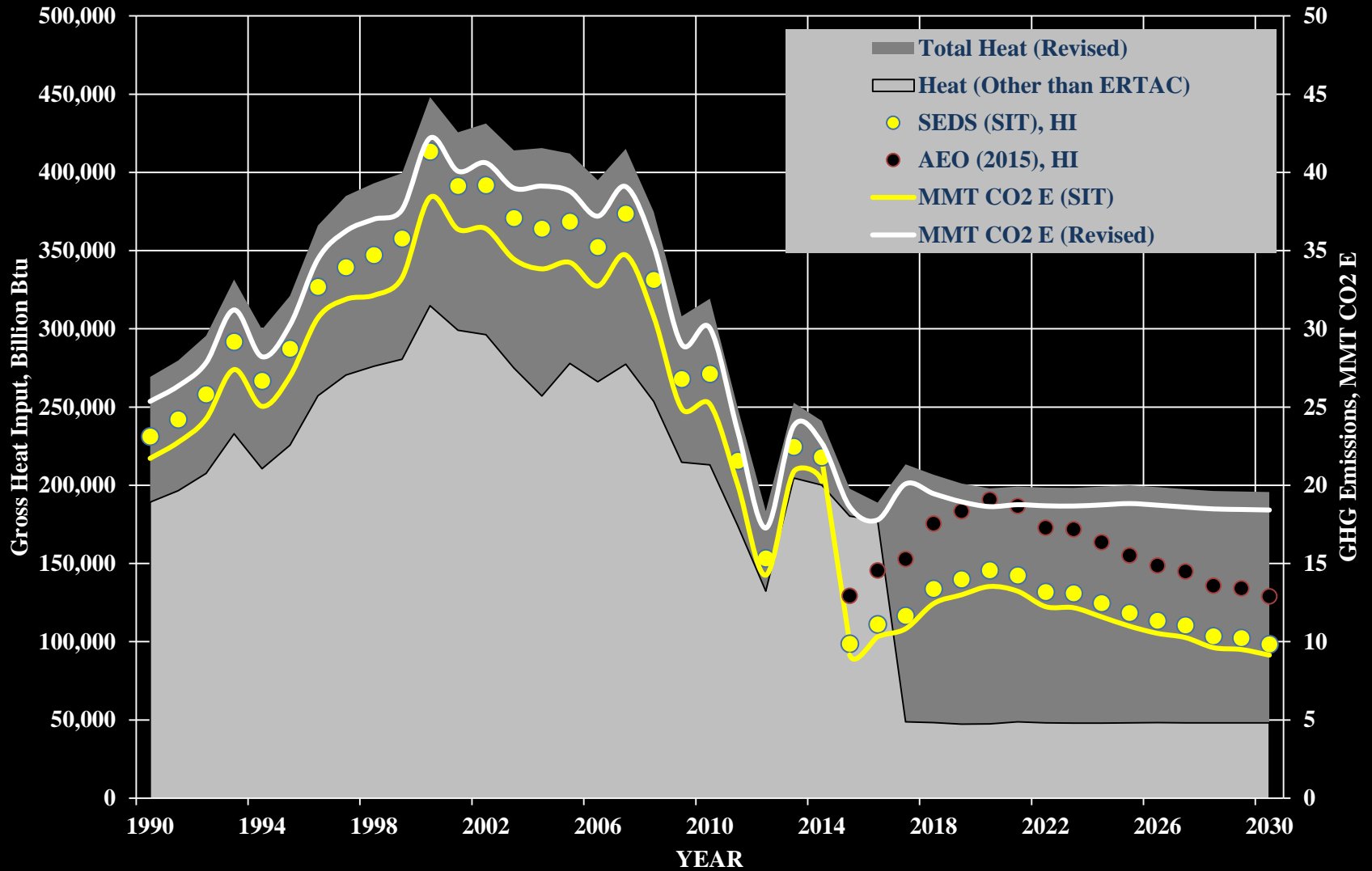


EMISSIONS –REVISED & SIT ASSESSMENT

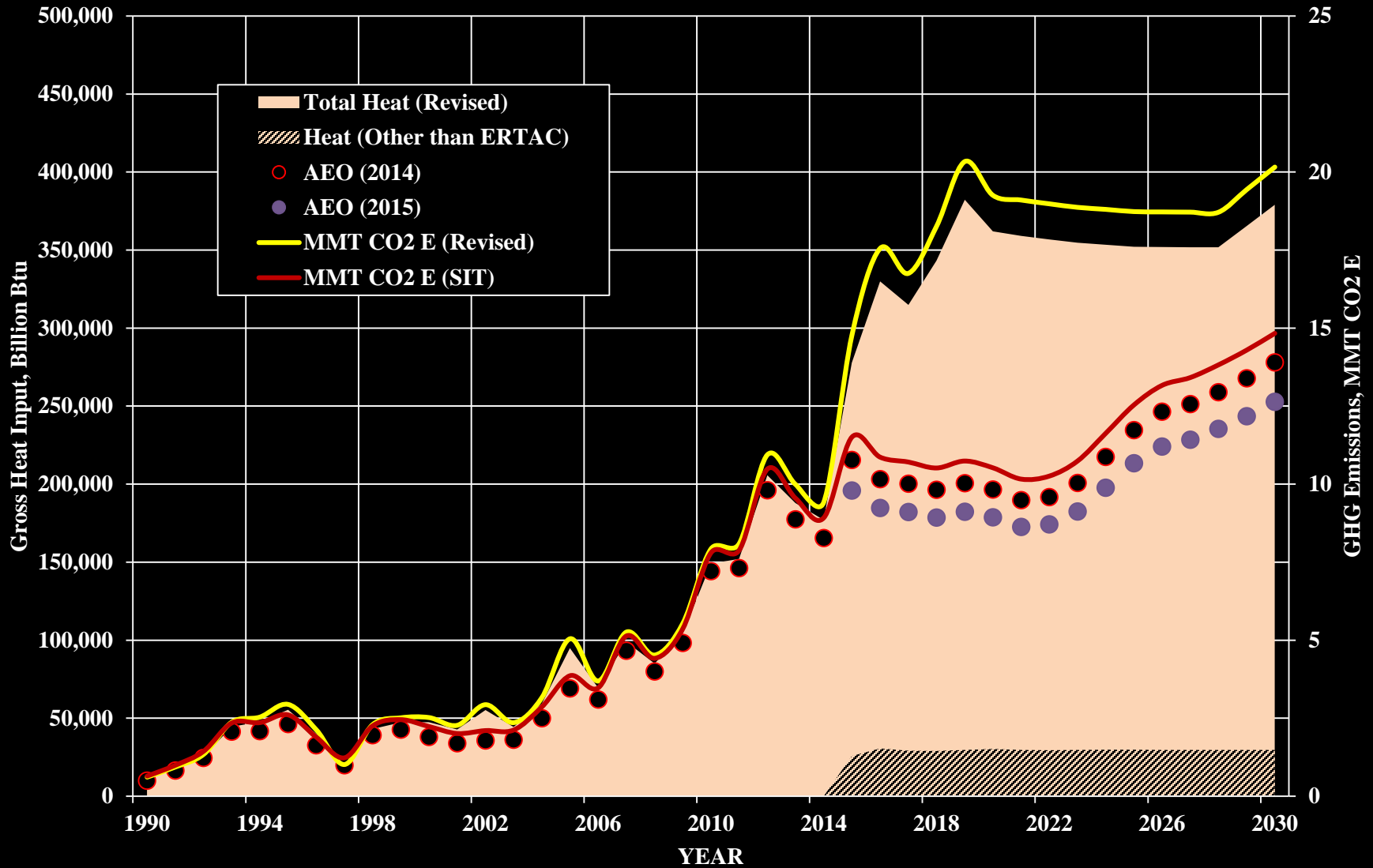


**SOLID LINES: REVISED; DOTTED: SIT VALUES;
EMISSIONS IN METRIC TONS EQUIVALENT CO₂**

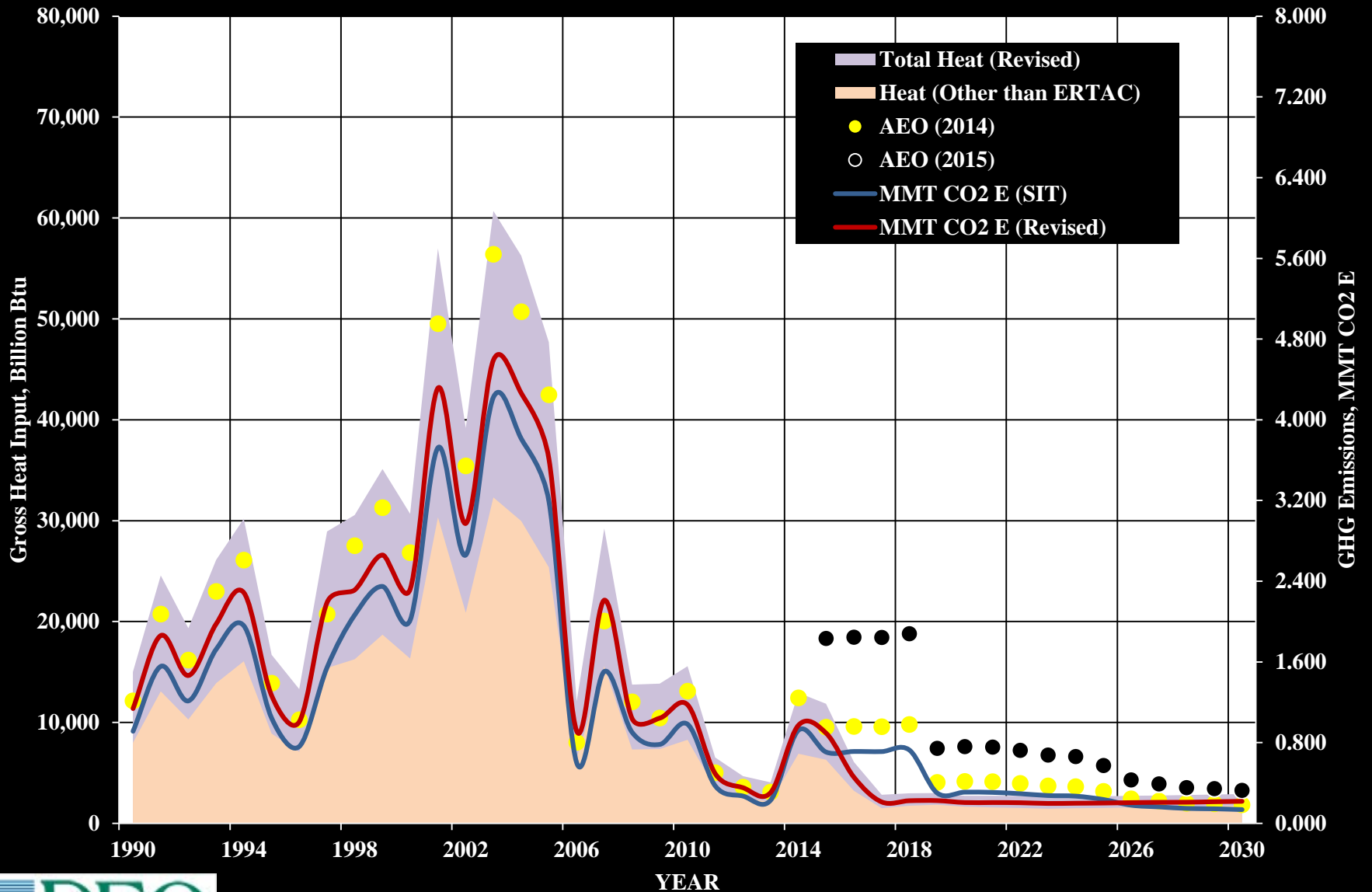
ENERGY USAGE & EMISSIONS TREND - COAL



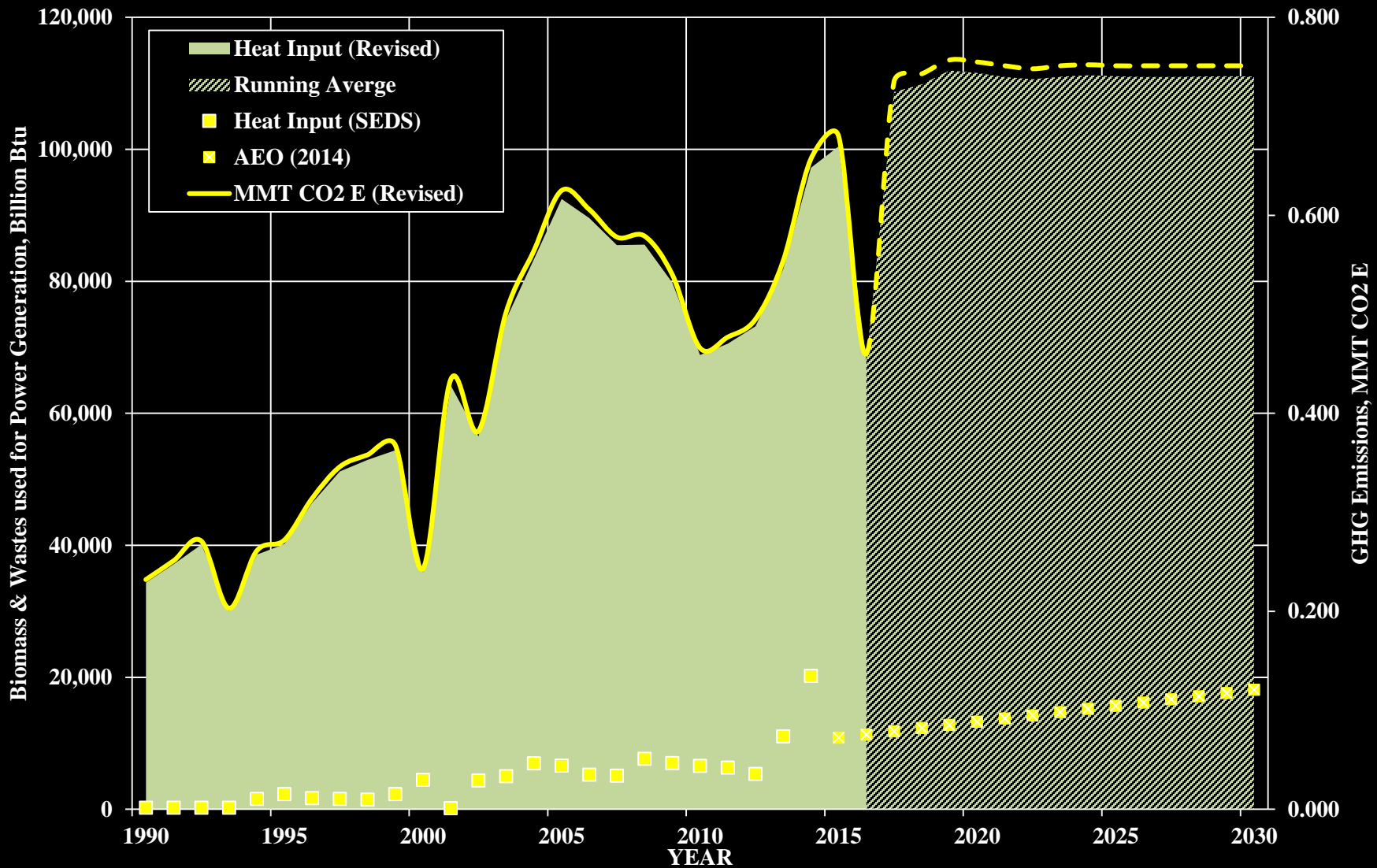
ENERGY USAGE & EMISSIONS TREND – NATURAL GAS

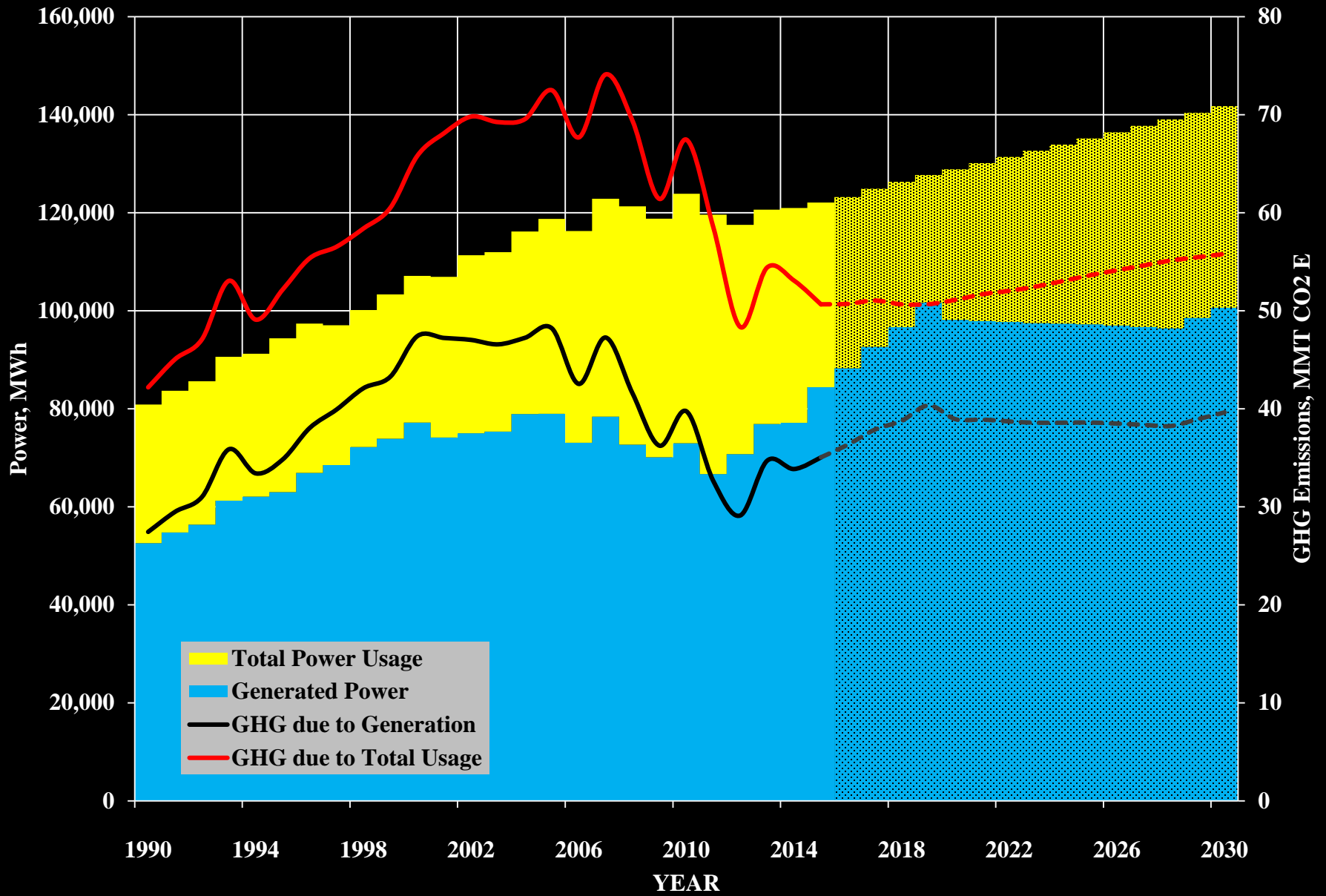


ENERGY USAGE & EMISSIONS TREND – PETROLEUM



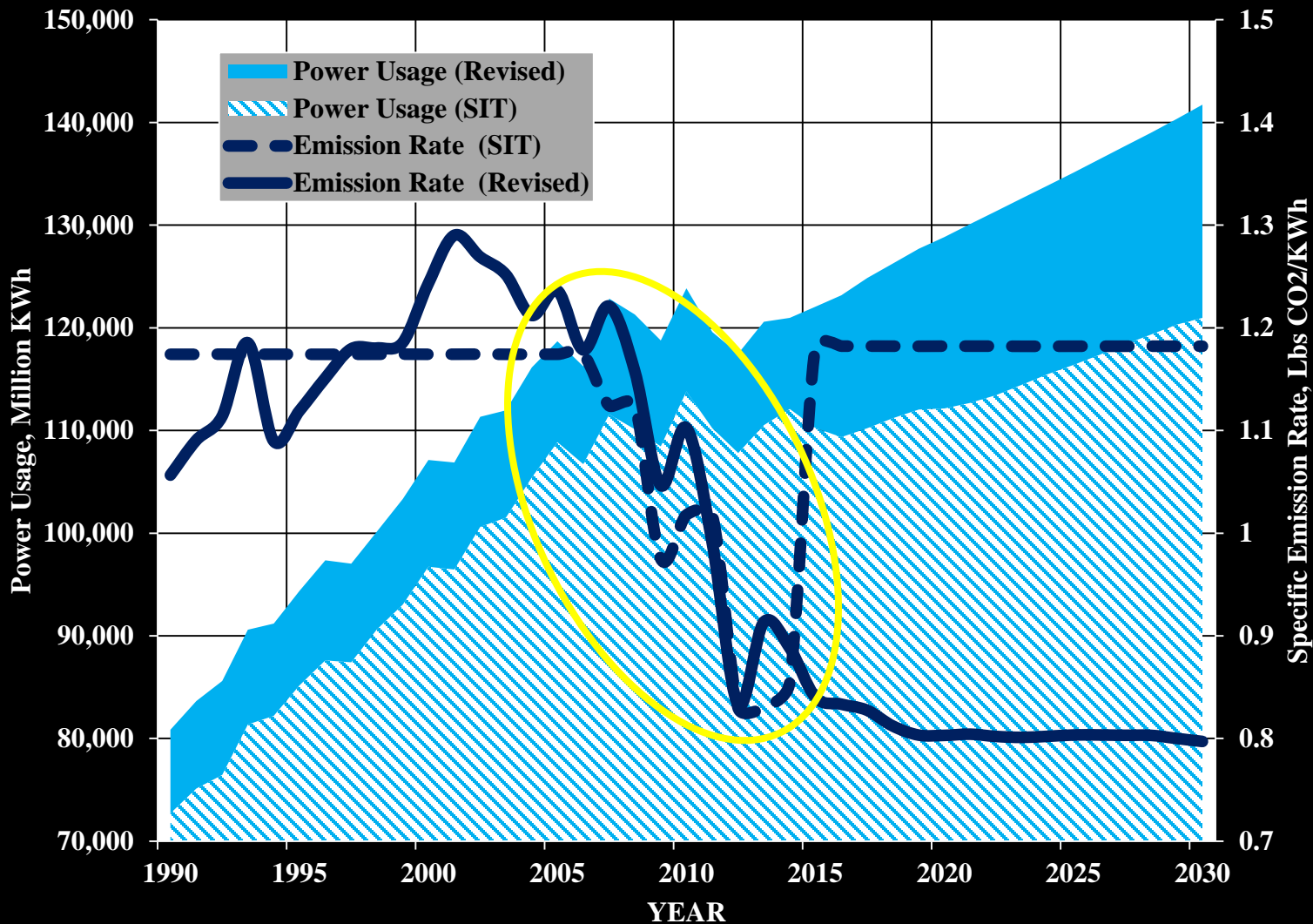
ENERGY USAGE & EMISSIONS TREND – WASTES & BIO





**TREND IN EMISSIONS RELATED TO
GENERATED POWER AND USAGE**

COMPARISON OF REVISED SPECIFIC EMISSIONS RATE, LBS CO₂/KWh, WITH VALUES USED IN SIT



A COMPARISON OF SPECIFIC EMISSIONS RATES BASED ON REVISED ESTIMATES INCLUDES BOTH GENERATED & IMPORTED POWER ARE IN CLOSE AGREEMENT WITH SIT ASSUMPTIONS FOR ESTIMATING EMISSIONS BASED ON USAGE IN THE RECENT PAST.

FOR FUTURE YEARS, THEY ARE FAR APART. REASONS ARE TWO. IN SIT THE ASSUMED RATE IS THE HIGHEST OF THE PAST. IN THE REVISED ESTIMATE, NON-FOSSIL GENERATION, PARTICULARLY CLEAN NUCLEAR & HYDRO AND OTHER EMISSION INEFFECTIVE WASTES & BIOMASS GENERATION ARE GRWON ON FIVE YEAR RUNNING AVERAGE.

ALSO, LOWER RATES ARE COMPARABLE TO RECENT PAST.

SUGGESTIONS FOR A COMPREHENSIVE GHG EMISSIONS ESTIMATION FROM POWER SECTOR

- **USE SOURCE BASED DETAILED ENERGY CONSUMPTION DATA (ELECTRICITY SECTION OF EIA);**
- **INCLUDE EMISSIONS OF SF₆ USED IN T & D EQUIPMENT;**
- **INCLUDE EMISSIONS DUE TO POWER USED BUT NOT GENERATED;**

ALTERNATELY,

- **FOLLOW 'USE BASED' APPROACH SUGGESTED IN SIT
KEY IS TO ASSUME CORRECT RATE VALUE**
- **EVOLVE RATE ANNUALLY BASED ON NATIONAL
INVENTORY FOR USE BASED ON CONSUMPTION**

BENEFITS

of accurate emissions estimates

- **STRENGTHEN
STATE IMPLEMENTATION PLANS**
- **BETTER APPRECIATION
OF RENEWABLE ENERGY IMPACT
IN FOSSIL POWER SUBSTITUTION**

Acknowledgements:

- Thank You All for Listening;
- EPA/EIC2017 Organizers for the Opportunity;
- MARAMA/VADEQ for Financing;
- Thomas R. Ballou, Director, Air Data Analysis
- Doris MacLeod ,VADEQ for ERTAC inputs
- VADEQ.