

# Water and Energy in the Delaware River Basin

## Constellation Energy, Limerick Nuclear Generating Station

December 9, 2022

Michael Thompson, P.E.

*DRBC Water Resource Planning Section  
Water Resource Engineer*

and

Chad Pindar, P.E.

*DRBC Water Resource Planning Section  
Manager*



# 1. DRBC's Water Withdrawal and Consumptive Use Study

DRBC remains operational, but its West Trenton, NJ Office Building is closed & staff are working remotely until further notice. See homepage for more info.

Water Withdrawal & Consumptive Use Estimates (1990-2017) & Projections Through 2060

14 October 2021

Water Withdrawal and Consumptive Use Estimates for the Delaware River Basin (1990 - 2017) With Projections Through 2060

Report 2021-4

DRBC's Water Supply and Planning Program focuses on water security - ensuring that there is a sustainable supply of suitable quality water in the Delaware River Basin (DRB).

To support this water resource management goal, the DRBC studies water use and plans for future water availability in the DRB.

In October 2021, the DRBC published a new report titled *Water Withdrawal and Consumptive Use Estimates for the Delaware River Basin (1990-2017) with Projections through 2060*. The report analyzes 30 years of historic withdrawal data and projects withdrawal demands to the year 2060.

**Report:**

- [View/Download Report](#) (pdf 40 MB)
- [View News Release](#) (issued October 19, 2021)

**Report Goals:**

- Analyze existing water withdrawal and consumptive use data for the DRB from 1990-2017
- Project Water Withdrawals through 2060


**Report Focus:**


- Major Water Withdrawal Sectors: Public Water Supply, Power Generation, Industry, Irrigation, Mining, Self-Supplied Domestic, Out-of-Basin Diversions & other
- Consumptive Use: Water that is withdrawn/taken from the Basin, but not returned


**Key Conclusions:**


- Most water withdrawals are coming from surface water (~95%), with the remainder from groundwater.


## You can:

- 

Download the report (~40 MB)  
(Best viewed with Adobe)
- 

Download the dataset (~10 MB)  
MS Excel File (no macros)
- 

Download high resolution maps  
from the report
- 

Reference past presentations  
given on this work
- 

Interact with the Power BI data  
visualization tool

Please note: this application works best using Chrome. While you can zoom in, the application is best viewed at 100%. Page 1/2 offers data for the entire Delaware River Basin; page 2/2 is for the Southeastern Pennsylvania Groundwater Protected Area (SEPA-GWPA).

Select model parameters:

Withdrawal  
Consumptive Use

Reset Filters

Getting started?

Click a year to update the map

Year

Water withdrawals from the Delaware River Basin (historical & projected)

Withdrawal (MGD)

Year

LEGEND (MGD)

- NRW/CFP
- 0 - 1
- 1 - 5
- 5 - 10
- 10 - 100
- 100 - 500
- 500+

Sector

- PWS
- SSD
- DIV
- MIN
- IRR
- OTH
- HYD
- THM

DATA SET

- Select all
- Basin Model
- Historical Data

HUC-8 WATERSHED

- Select all
- Brandywine-Christina
- Broadkill-Smyrna
- Cohamsey-Maurice
- Crosswicks-Neshaminy
- East Branch Delaware
- Lackawaxen
- Lehigh
- Lower Delaware
- Middle Delaware-Mongaup-Brodhead
- Middle Delaware-Musconetcong
- Schuylkill
- Upper Delaware

SECTOR

- Select all
- Public Water Supply
- Self-Supplied Domestic
- Out-of-Basin Diversion
- Industrial
- Mining
- Irrigation
- Other
- Hydroelectric Power
- Thermoelectric Power

WATER

- Select all
- GW
- SW

STATE

- Select all
- DE
- NJ
- NY
- PA

Map Selections:

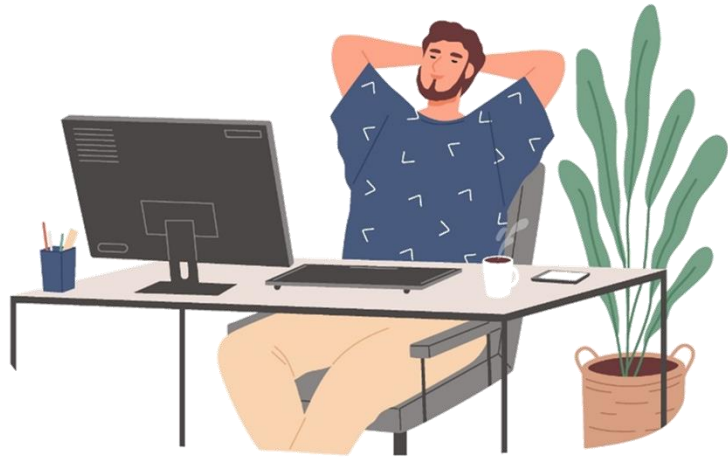
Basin ID: ALL

Sector: ALL

Years: 2022

Note: Color coded values in the map above correspond to total subbasin values based on the selected variables. If more than one year is selected, the map reflects the summation of multiple years and not the annual average rate as suggested by the legend units. For this reason the map should be used only for relative comparison of subbasins when viewing multiple years of data. All surface water

## 2. Why are we projecting withdrawal data?



### Is there enough water to meet **future demands**?

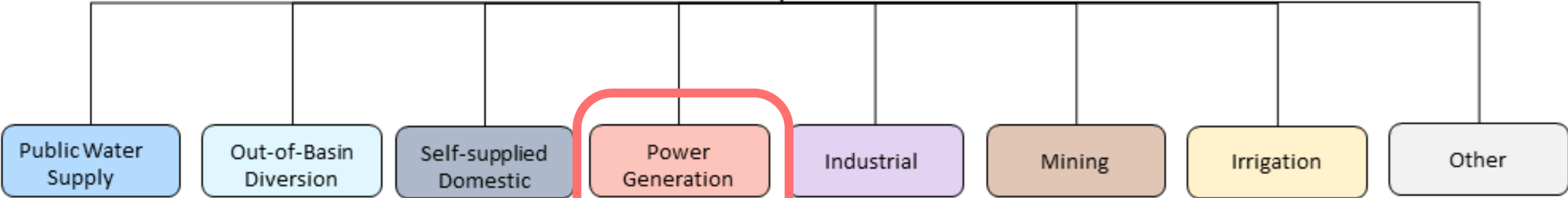
1. What are the current/future demands? ←
2. How does it compare against current allocations?
3. What about a repeat of the Drought of Record?
4. What about climate change?

# 3. Water use sectors in the DRB



The primary method is extrapolation of historic reported withdrawal data

Water Withdrawals in the Delaware River Basin



Report Link: [Section 3](#)  
Primary Method: Extrapolation of historic water withdrawal data

Report Link: [Section 3](#)  
Primary Method: Mean value based on a five-year average.

Report Link: [Section 4](#)  
Primary Method: Population estimate and per-capita rates.

Report Link: [Section 5](#)  
Primary Method: Extrapolation of historic water withdrawal data

Report Link: [Section 6](#)  
Primary Method: Extrapolation of historic water withdrawal data

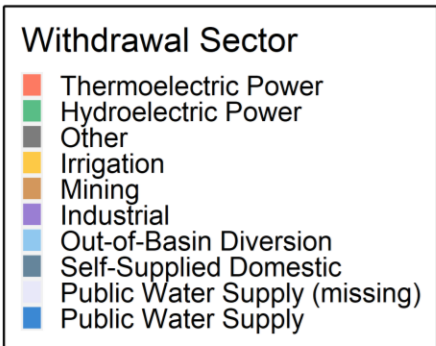
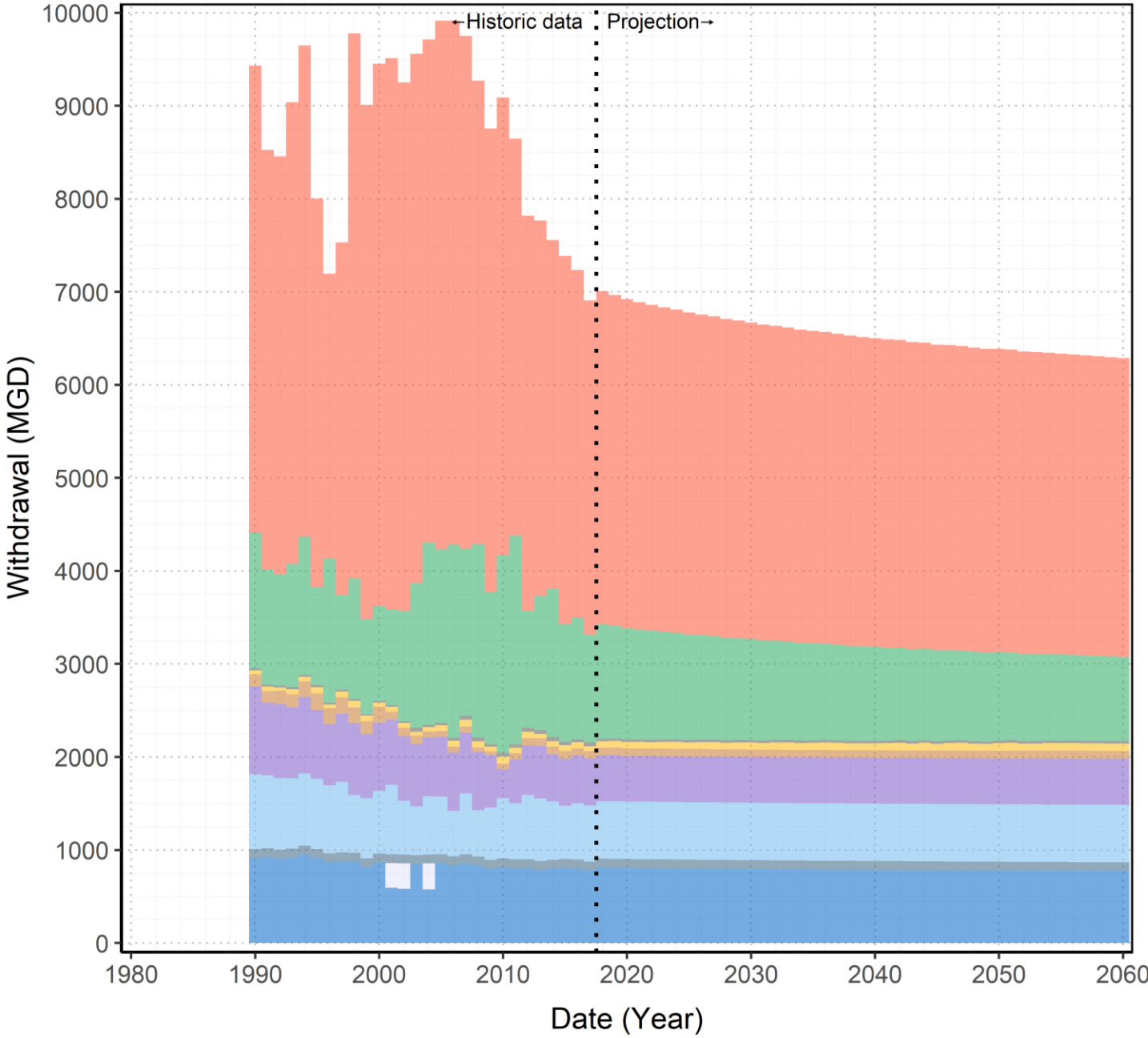
Report Link: [Section 7](#)  
Primary Method: Extrapolation of historic water withdrawal data

Report Link: [Section 8](#)  
Primary Method: Multivariate regression for temperature and precipitation.

Report Link: [Section 9](#)  
Primary Method: Extrapolation of historic water withdrawal data

The focus of this presentation

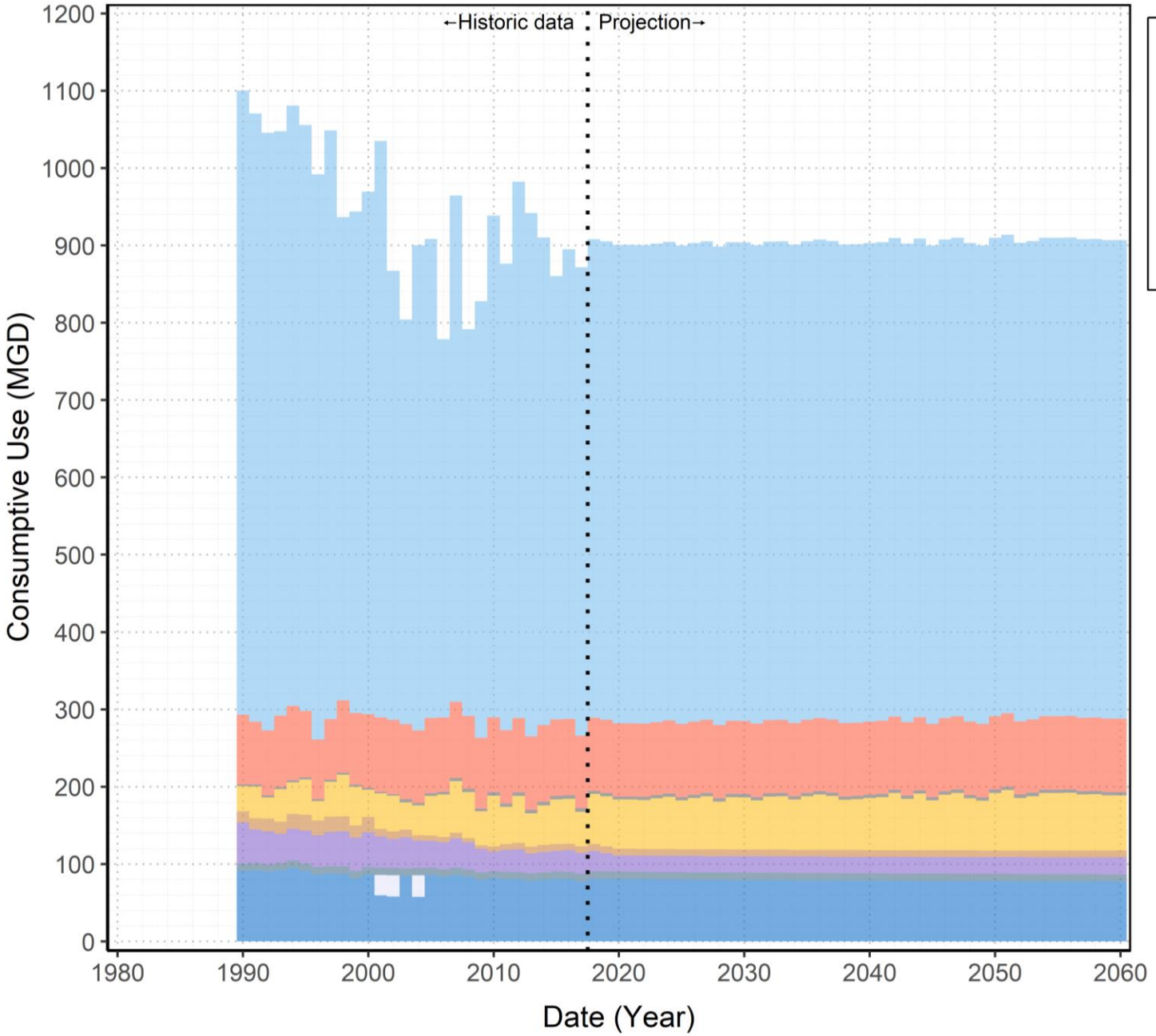
# Historic and projected water withdrawals from the Delaware River Basin



- **Peak withdrawals have occurred**
- **Thermoelectric** decreases since 2007 will plateau as coal-fired facilities using once-through are limiting
- **Public Water Supply** has shown and projects decreases despite historic and projected growing in-Basin population
- **Hydroelectric** withdrawals are significant; however, no consumptive use
- **Industrial** withdrawals historically decrease, but plateau



# Historic and projected consumptive use in the Delaware River Basin



**Withdrawal Sector**

- Out-of-Basin Diversion
- Thermoelectric Power
- Hydroelectric Power
- Other
- Irrigation
- Mining
- Industrial
- Self-Supplied Domestic
- Public Water Supply (missing)
- Public Water Supply

- **Consumptive use projected to remain relatively constant**
- **Largest consumptive use is Out-of-Basin Exports under a U.S. Supreme Court Decree**
- **Thermoelectric** consumptive use constant despite decreased withdrawals due to changes in technology
- **Irrigation** is significant and shows slight increases related to projected changes in climatic variables
- Significant **spatial variation** in terms of both withdrawal and consumptive use



# 5. Water-Energy Nexus



# Context: power in the Delaware River Basin, comparatively

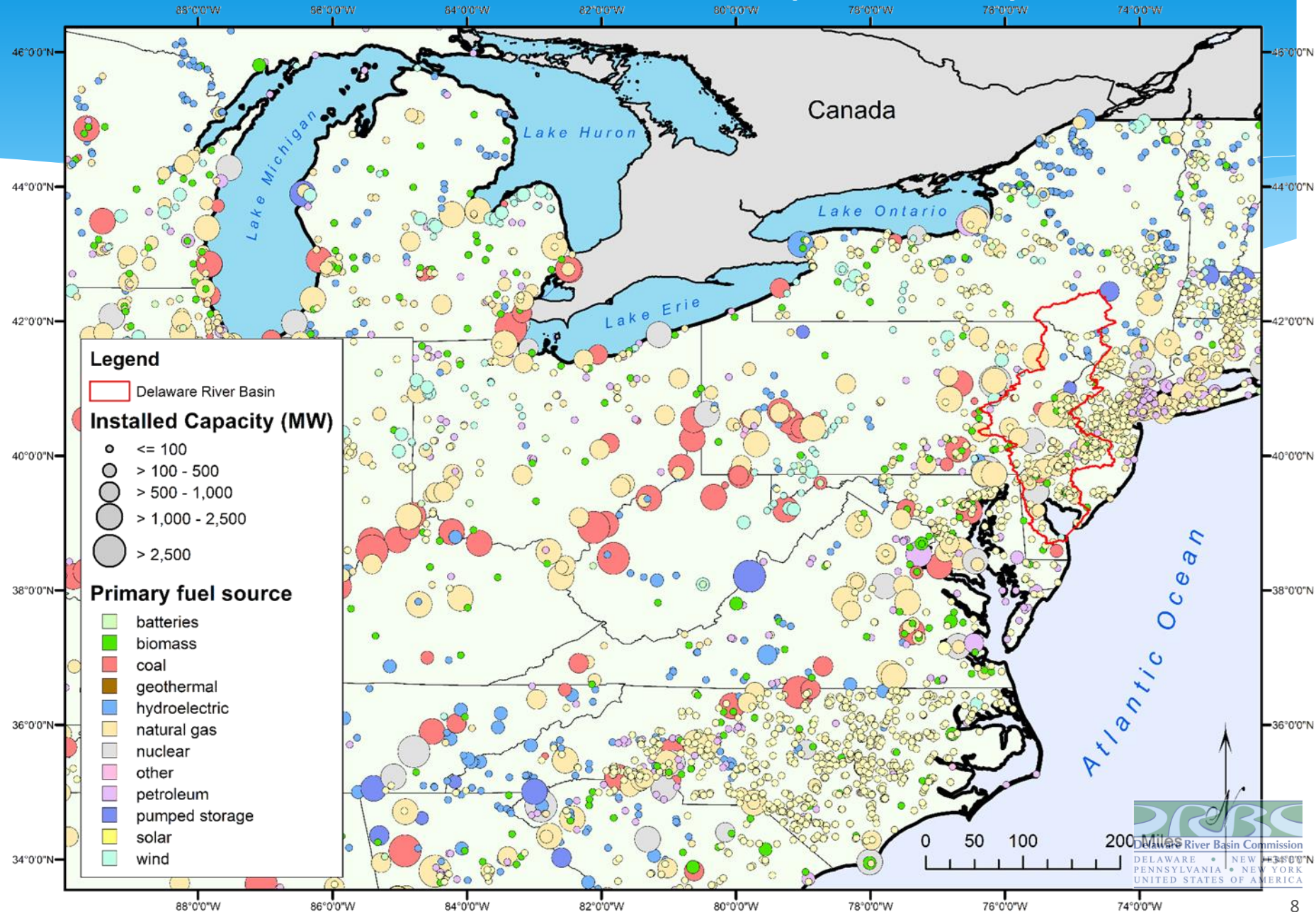
## Data sources:

EIA: *PowerPlants\_US\_202004.shp*

[https://www.eia.gov/maps/layer\\_info-m.php](https://www.eia.gov/maps/layer_info-m.php)

“Operable electric generating plants in the United States by energy source. This includes all plants that are operating, on standby, or short- or long-term out of service with a combined nameplate capacity of 1 MW or more.”

**Represents “current” facility conditions as of April 2020. Does not represent net generation, or historic fuels primary fuel types.**





# Context: power in the Delaware River Basin, comparatively

## Data sources:

EIA: *PowerPlants\_US\_202004.shp*

[https://www.eia.gov/maps/layer\\_info-m.php](https://www.eia.gov/maps/layer_info-m.php)

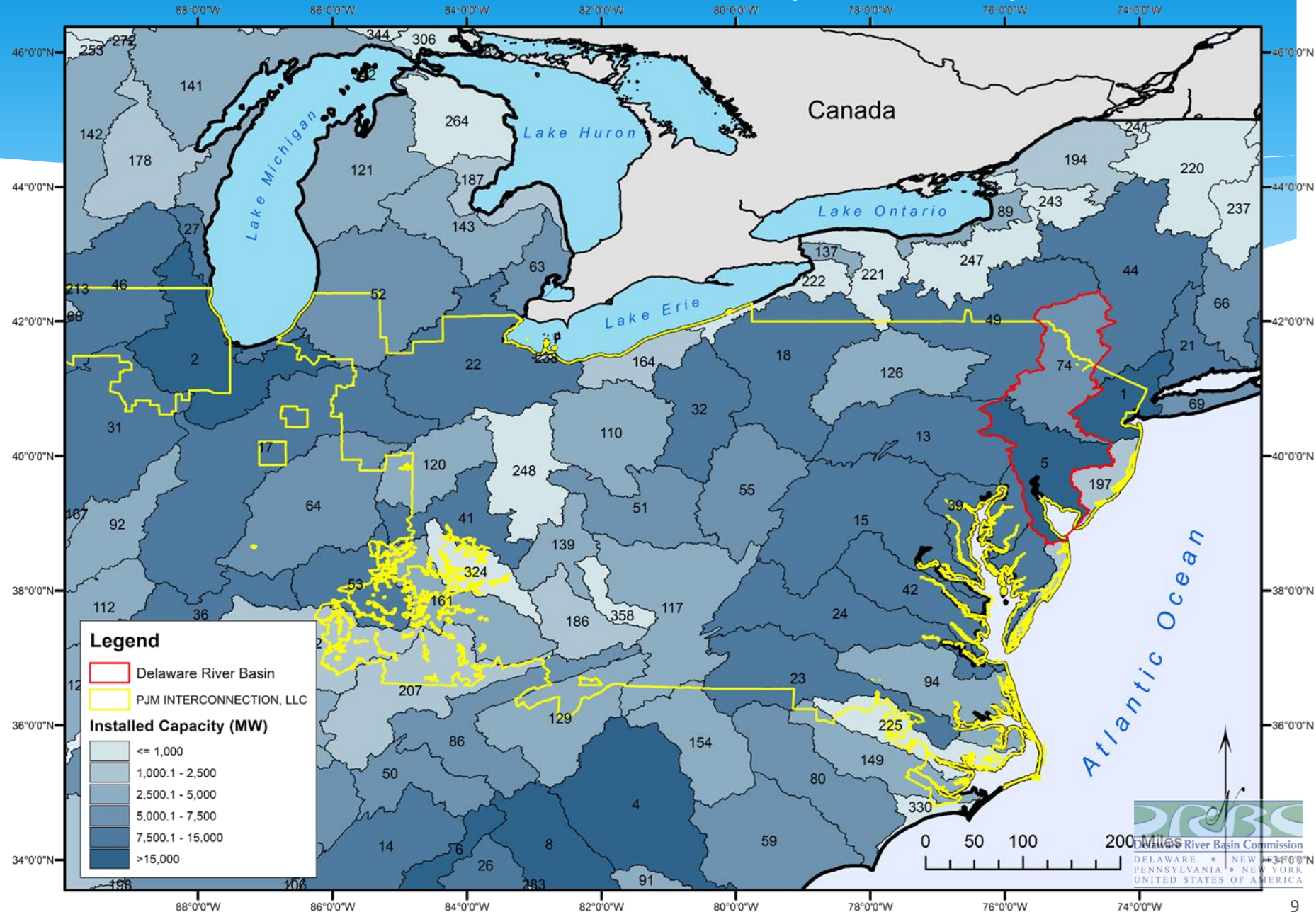
USGS: *WBD\_National\_GDB.gdb*

<http://prd-tnm.s3-website-us-west-2.amazonaws.com/?prefix=StagedProducts/Hydrography/WBD/National/GDB/>

## Some notes:

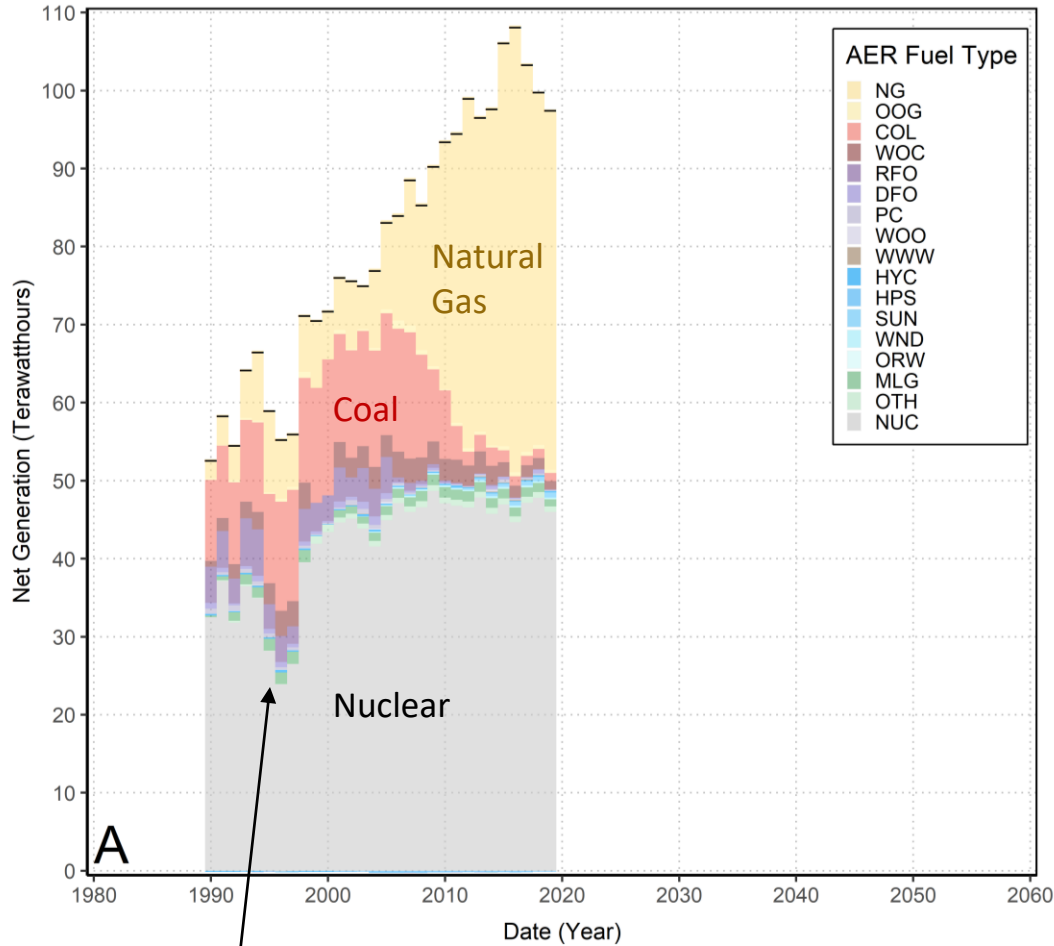
- Aggregate the installed capacity by HUC-6 code.
- 388 HUC-6 codes (excludes CN, GU, PR, MX, VI)
- 360 have installed capacity
- (020402) LDRW = 5<sup>th</sup> / 360
- (020401) UDRW = 74<sup>th</sup> / 360

Power in the DRB is comparably significant.

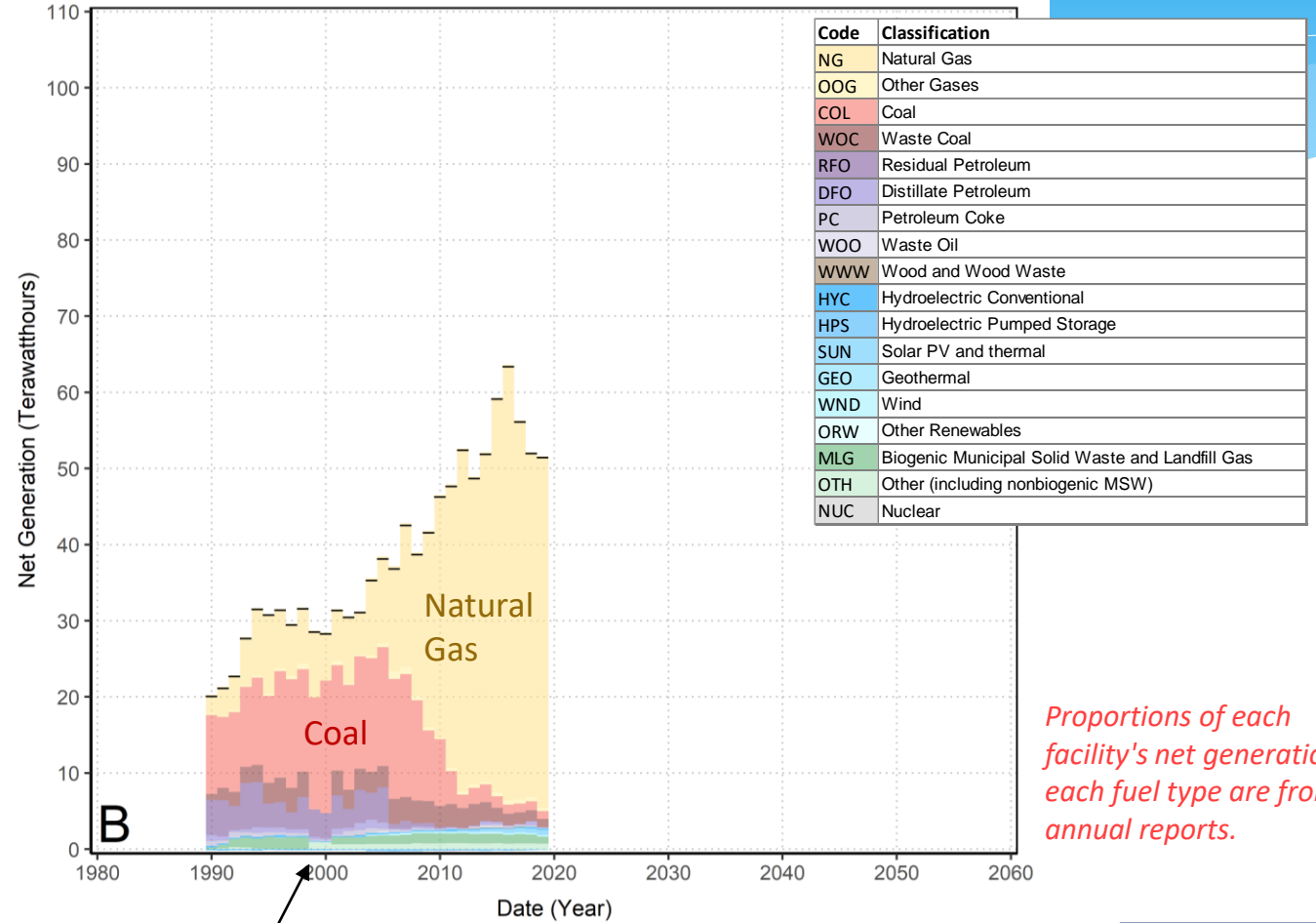


# Historic power data: DRB-facilities net gen. (AER fuel type)

All power generation facilities



Excluding nuclear power generation facilities



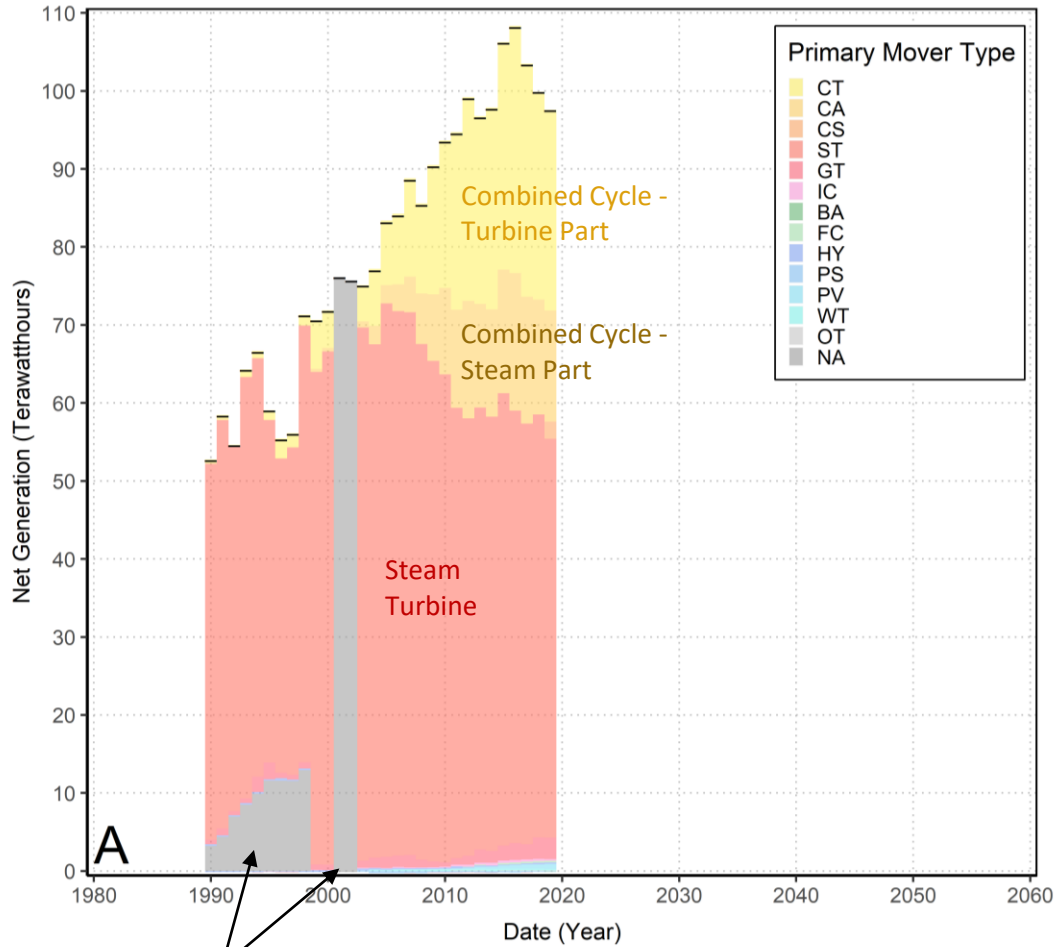
*Proportions of each facility's net generation to each fuel type are from annual reports.*

Salem Generating Station temporarily shut down around 1996 (including part of 1995 & 1997)

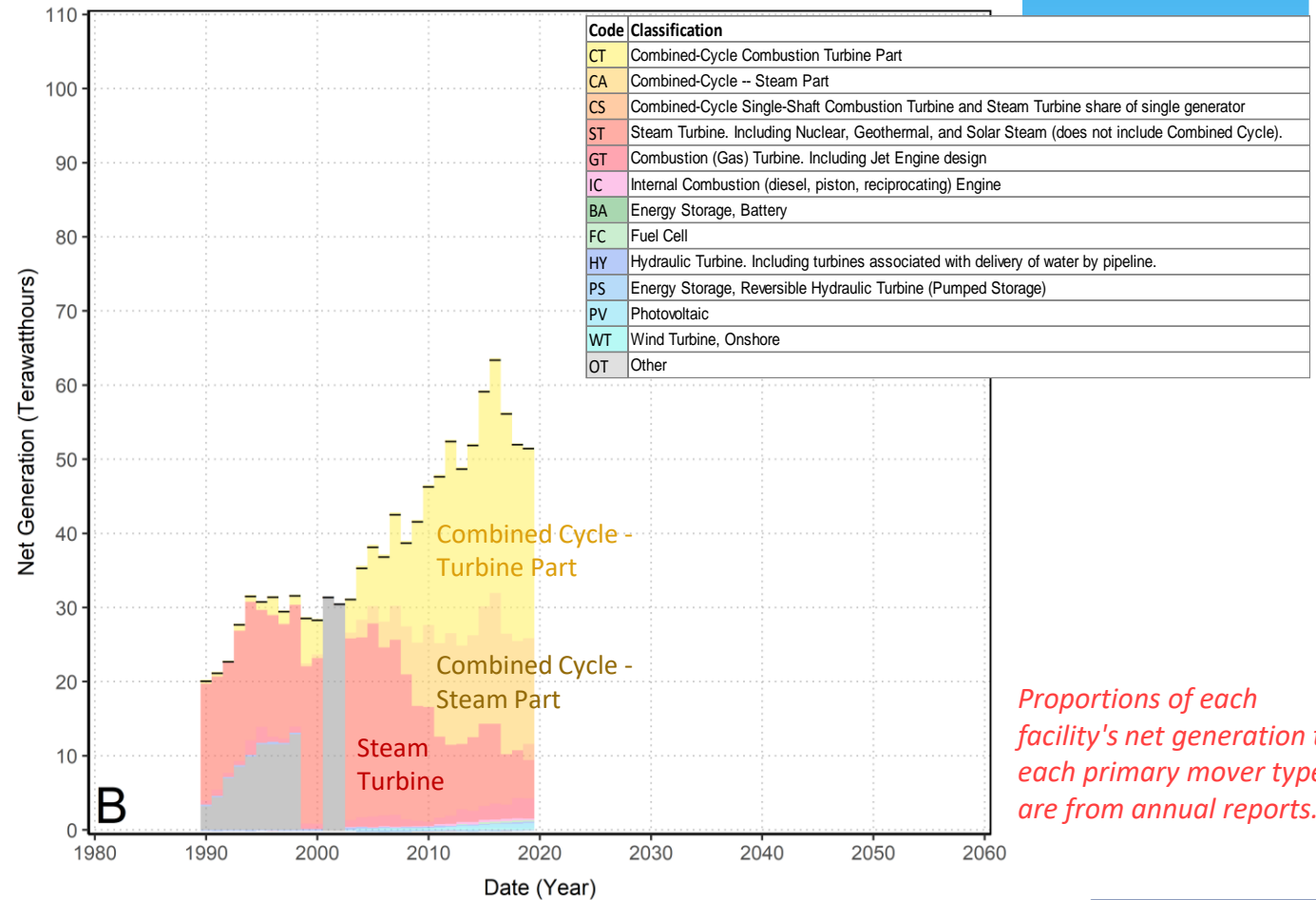
e.g., no data for "WOC" (1999-2000) due to manual classification of AER fuel types, given the best available data resolution. Likely captured as "COL"

# Historic power data: DRB-facilities net gen. (primary mover)

All power generation facilities



Excluding nuclear power generation facilities

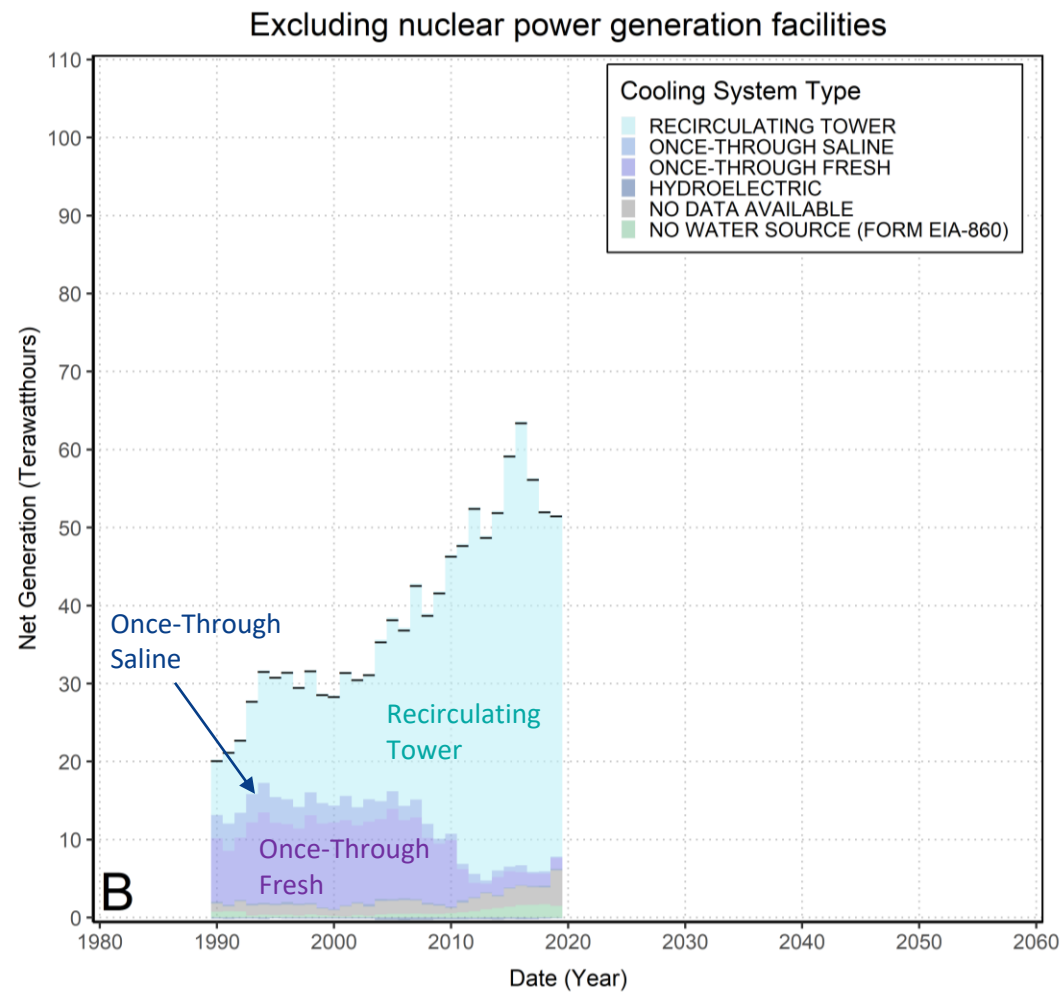
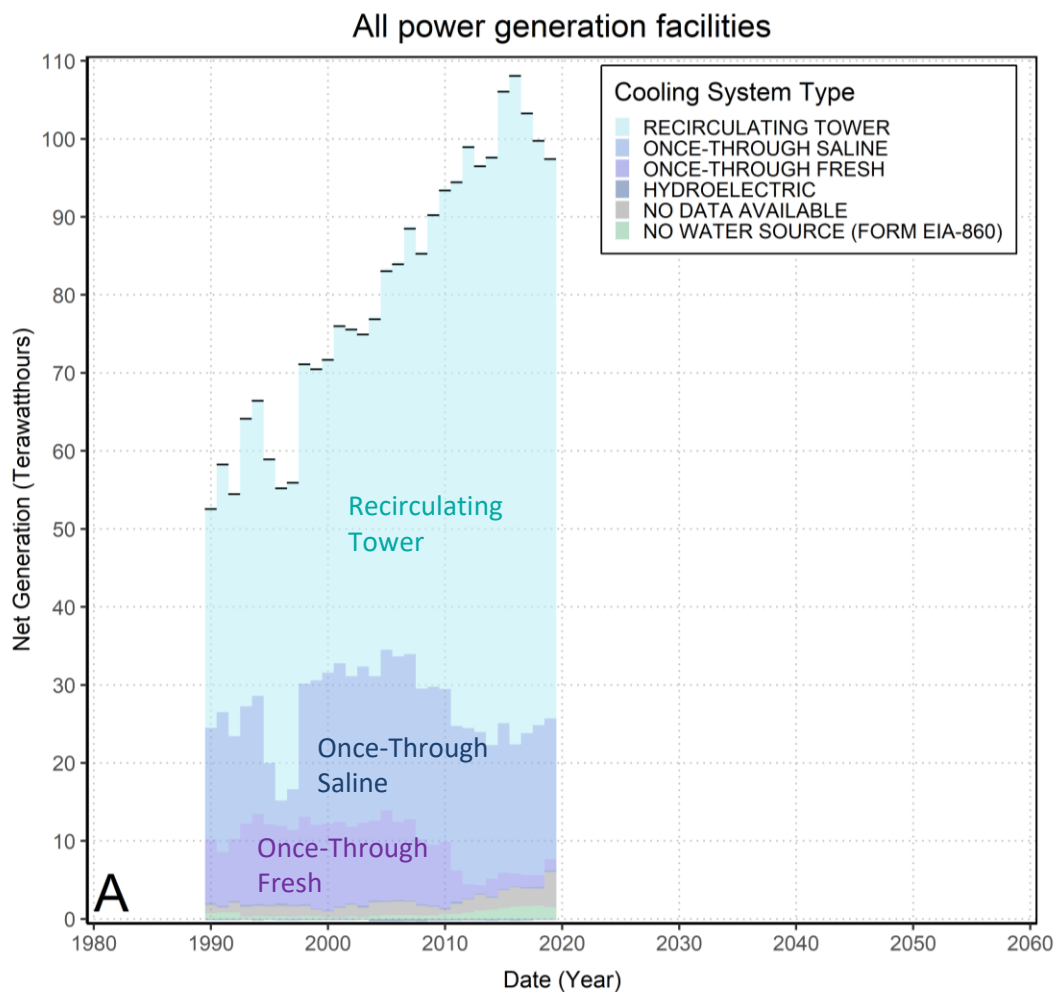


Code	Classification
CT	Combined-Cycle Combustion Turbine Part
CA	Combined-Cycle -- Steam Part
CS	Combined-Cycle Single-Shaft Combustion Turbine and Steam Turbine share of single generator
ST	Steam Turbine. Including Nuclear, Geothermal, and Solar Steam (does not include Combined Cycle).
GT	Combustion (Gas) Turbine. Including Jet Engine design
IC	Internal Combustion (diesel, piston, reciprocating) Engine
BA	Energy Storage, Battery
FC	Fuel Cell
HY	Hydraulic Turbine. Including turbines associated with delivery of water by pipeline.
PS	Energy Storage, Reversible Hydraulic Turbine (Pumped Storage)
PV	Photovoltaic
WT	Wind Turbine, Onshore
OT	Other

*Proportions of each facility's net generation to each primary mover type are from annual reports.*

Data gaps due to unavailable information reported to EIA forms

# Historic power data: DRB-facilities net gen. (cooling system)



*A single cooling system classification is assigned to each facility's historic net generation data (i.e., not reported annually).*

Cooling system classifications primarily obtained from supplemental data for (Harris & Diehl, 2019). Facilities which were not classified (mainly retired facilities) were classified by DRBC.

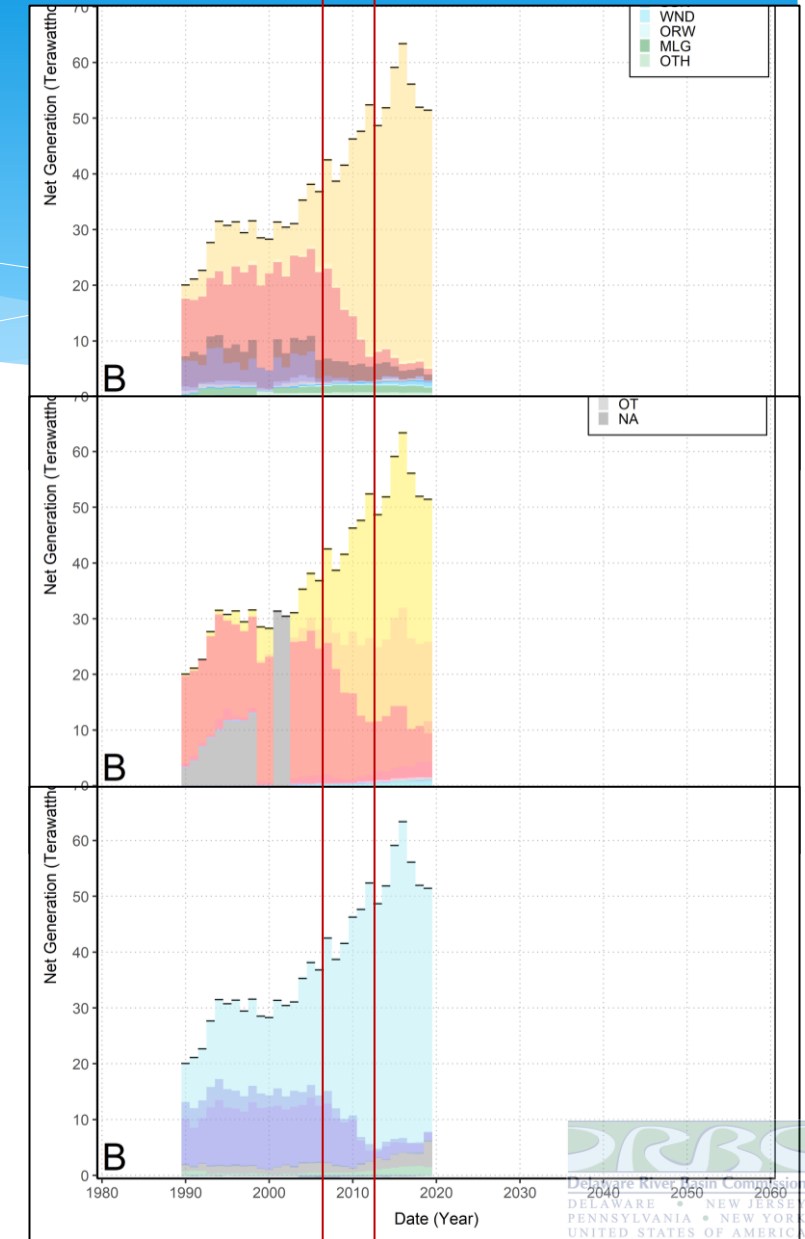
Harris, M. A., & Diehl, T. H. (2019). *Withdrawal and Consumption of Water by Thermoelectric Power Plants in the United States, 2015: Scientific Investigations Report 2019–5103*. Reston, Virginia. U.S. Geological Survey. <https://doi.org/10.3133/sir20195103>

# Notes on historic DRB net generation

## Key notes:

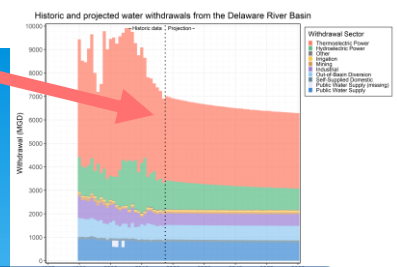
1. In the DRB, total net generation reached a **peak of 108.328 Twh in 2016**, followed by the largest decrease in recent history (-10.748 Twh), to 97.580 Twh in 2019.
2. Trends in 2007-2012:
  - Decreased production by coal-fired steam turbine facilities using once through cooling
  - Increase in facilities using natural gas, and those with combined cycle turbines (newer technology)
3. Counter to findings reported by (Harris & Diehl, 2019) for 2010-2015 where the national net generation decreased ~7%, the DRB increased ~13.6%

Timeframe between lines:  
2007-2012

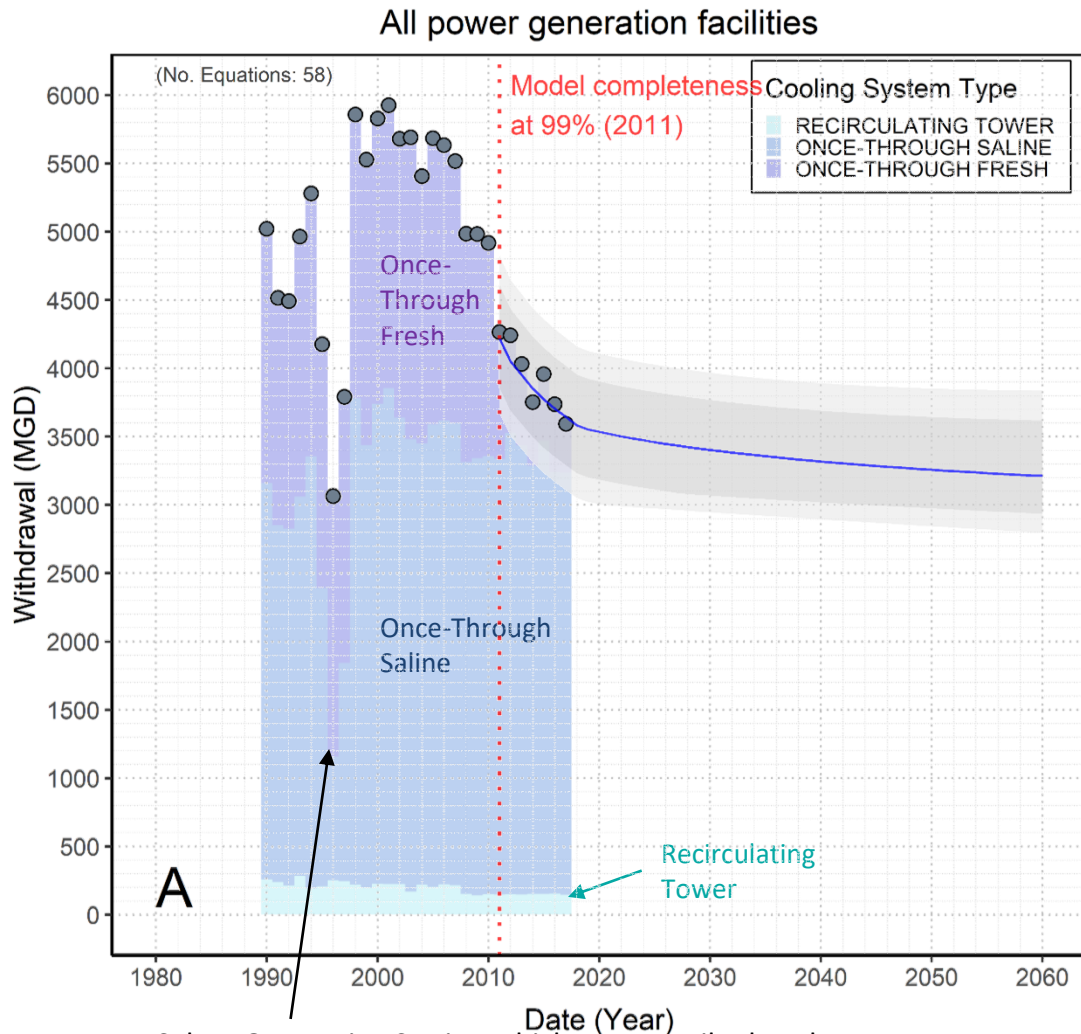


Non-nuclear facilities

These are notes based on observations of reported data. It is understood that regulations such as Clean Air Act, Clean Water Act and market forces have influenced the observed trends; however, it is not in the scope of this study to determine such cause-and-effect relationships.



# Thermoelectric: all facilities (water withdrawals)



Salem Generating Station which temporarily shut down around 1996, uses once-through saline water cooling (including part of 1995 & 1997)

## Regarding withdrawal data:

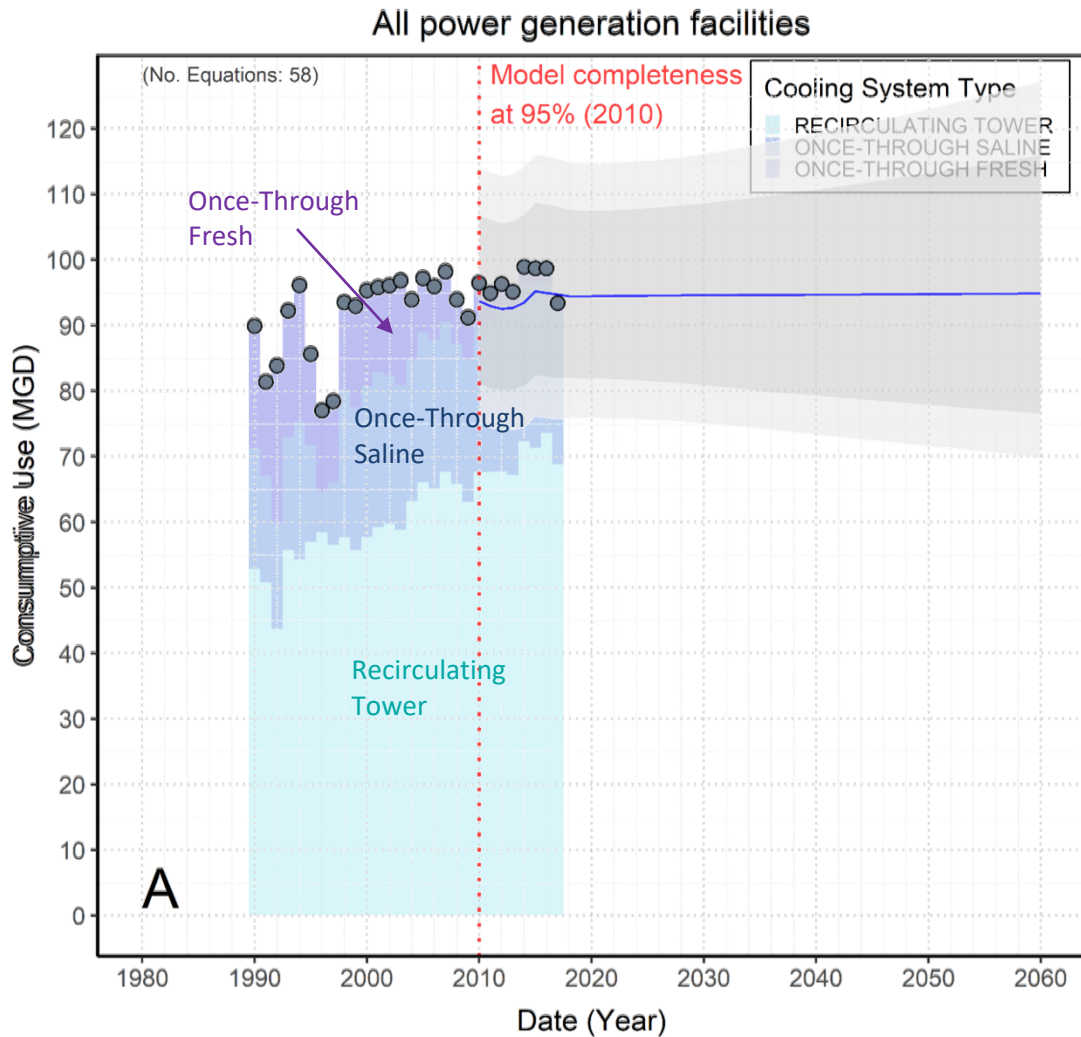
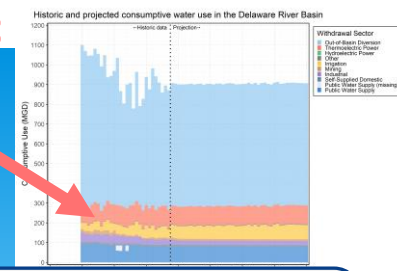
1. Overall, water withdrawals by thermoelectric facilities appears to have peaked around the year 2000 with a reported annual average of about 5,927 MGD (*in 2001*).
2. The decrease in total withdrawal from 2007-2017: 1,923 MGD (~34.8%)
3. Most decreases associated with facilities using once-through freshwater cooling systems.
4. Findings are generally consistent with those estimated nationally by the model presented in in [Harris & Diehl, 2019](#).

## Regarding projections:

1. Projected continued decrease 2017-2060 (430 MGD, 11.7%) with dramatic plateau (non-nuclear facilities)
2. Uneven predictive intervals, skewed higher (when a predictive interval for an individual facility is calculated to be negative, it is instead taken as zero)

# Thermoelectric: all facilities (consumptive use)

Thermoelectric  
consumptive  
use



## Regarding consumptive use data:

1. Relatively stable over the last 20 years:  
Average annual value of 95.7 MGD (1998-2017).
2. Consumptive increasingly attributed to facilities using recirculating cooling.
3. Nationally, the model in [Harris & Diehl, 2019](#) estimated that thermoelectric water consumption decreased about 21% between 2010 and 2015. The DRB appears to be counter to the national trend  
*(note: a national trend is likely inherently comprised of many varying sub-trends).*

## Regarding projections:

1. The same projection equations as total water withdrawal... each projection equation had a CUR applied to it.  
(The same as calculating the consumptive use data).
2. Aggregated projections create an “average model” of about 93 MGD, predictive intervals relatively symmetric.

# 6. Questions



Michael Thompson, P.E.  
Water Resource Engineer

---

Delaware River Basin Commission  
E: [Michael.Thompson@drbc.gov](mailto:Michael.Thompson@drbc.gov)  
P: (609) 883-9500 ext. 226



Chad Pindar, P.E.  
Manager – Water Resource Planning Section

---

Delaware River Basin Commission  
E: [Chad.Pindar@drbc.gov](mailto:Chad.Pindar@drbc.gov)  
P: 609-883-9500 ext. 268