Water and Energy in the Delaware River Basin

Constellation Energy, Limerick Nuclear Generating Station

December 9, 2022

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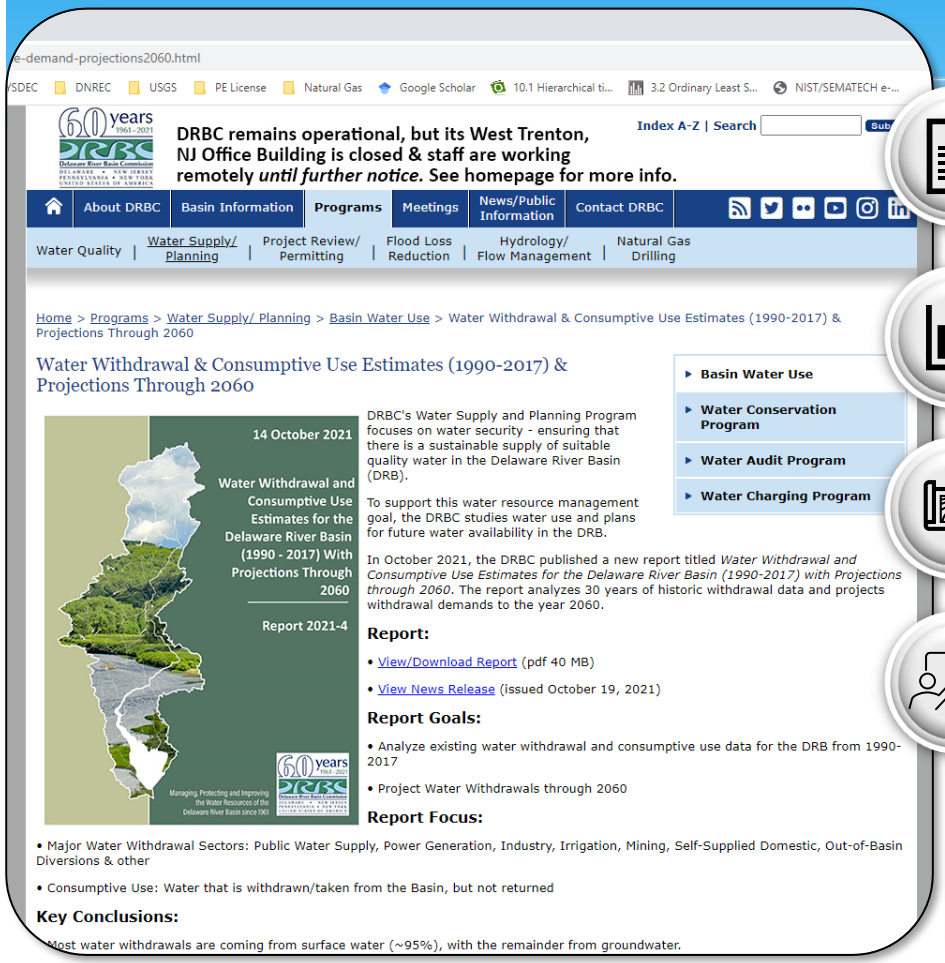
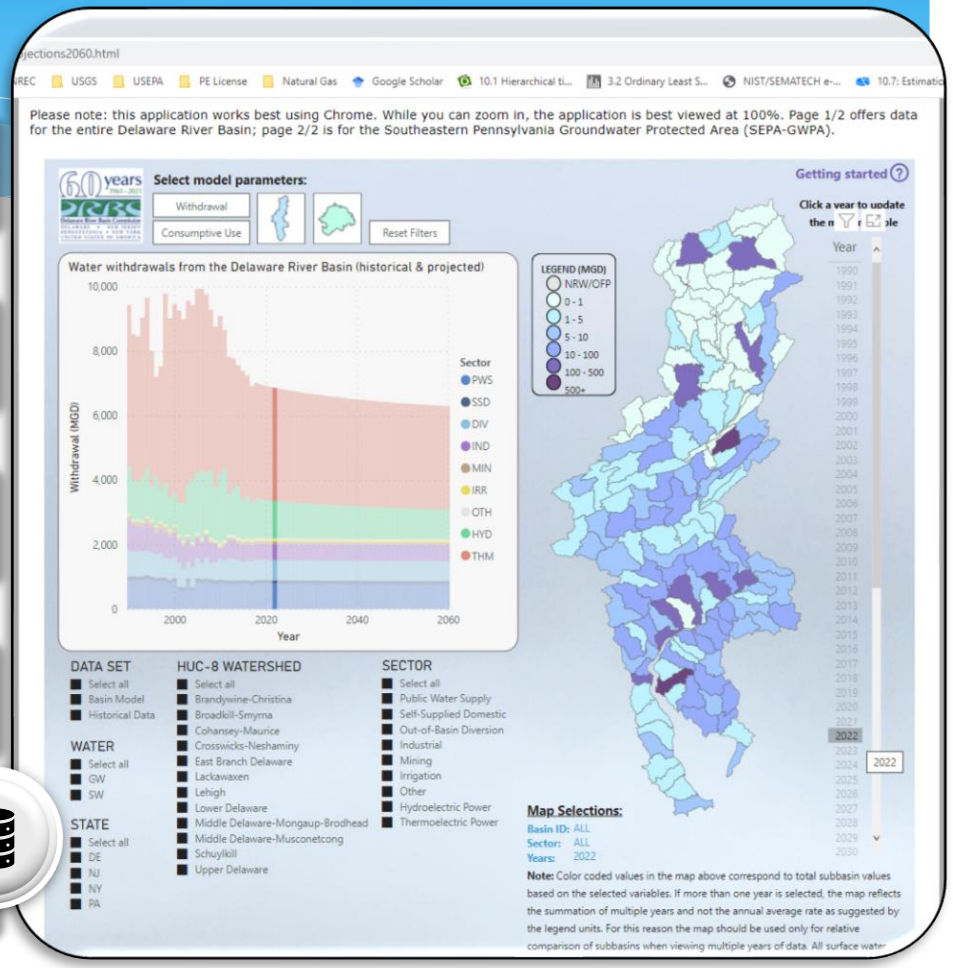
1. DRBC's Water Withdrawal and Consumptive Use Study



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



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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?

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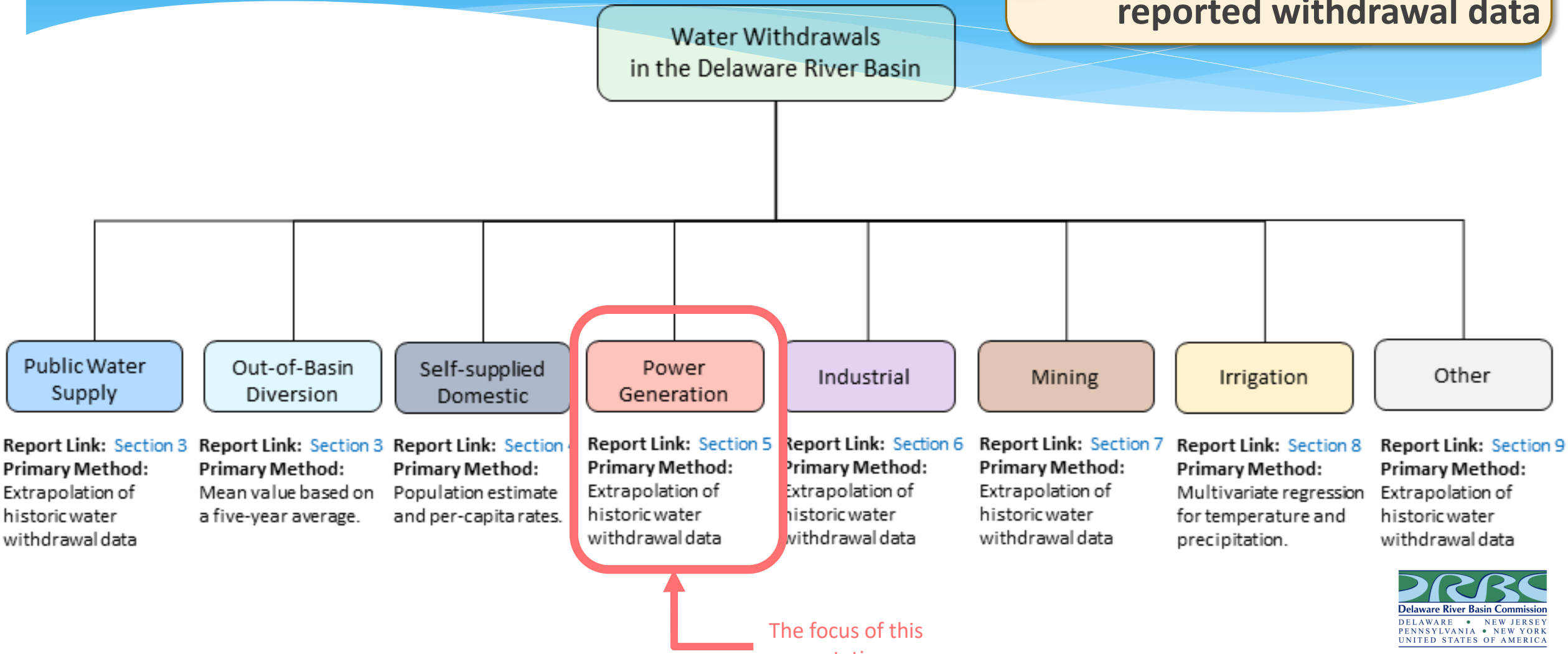
3. Water use sectors in the DRB

The primary method is extrapolation of historic reported withdrawal data



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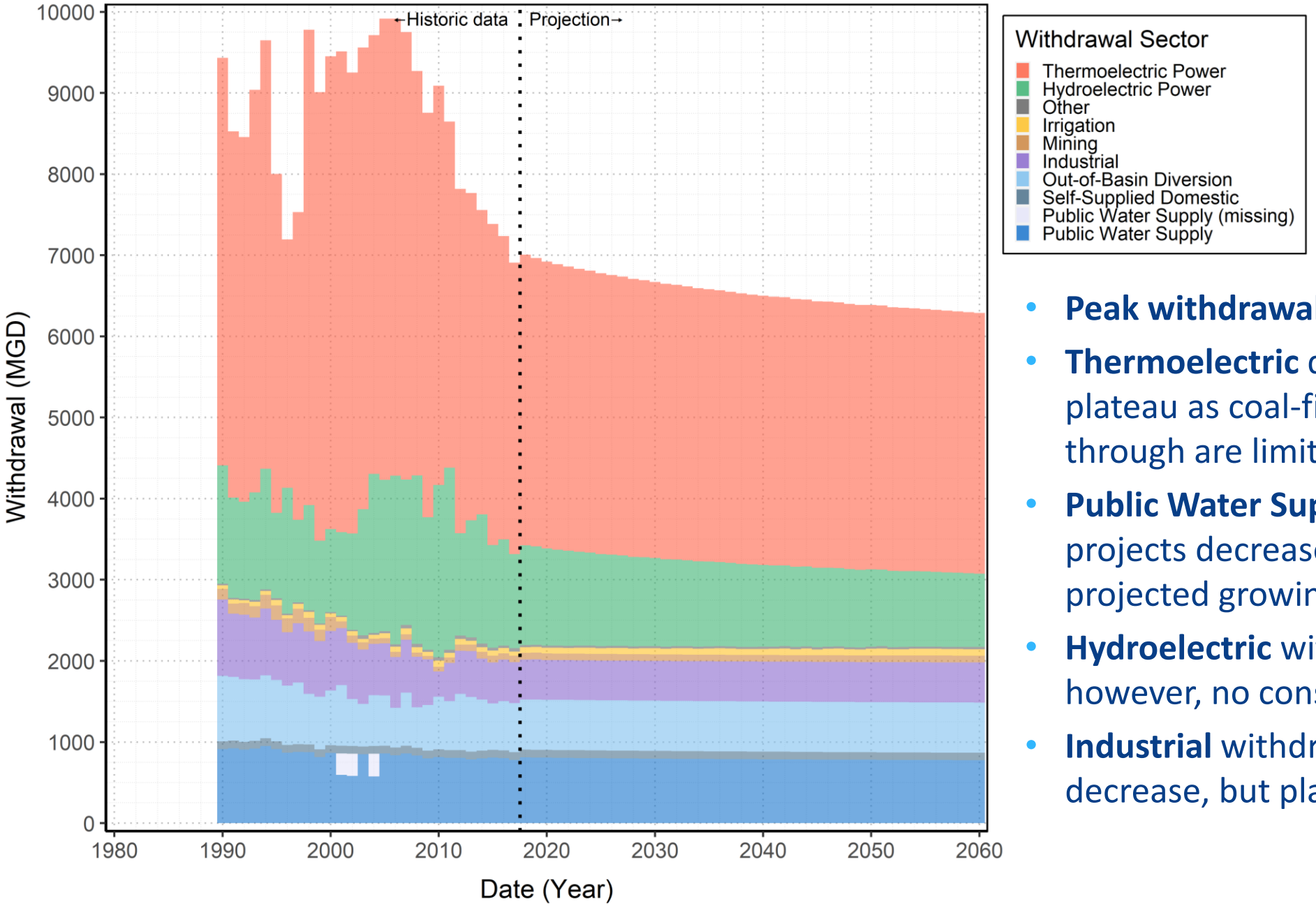
Historic and projected water withdrawals from the Delaware River Basin



- **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

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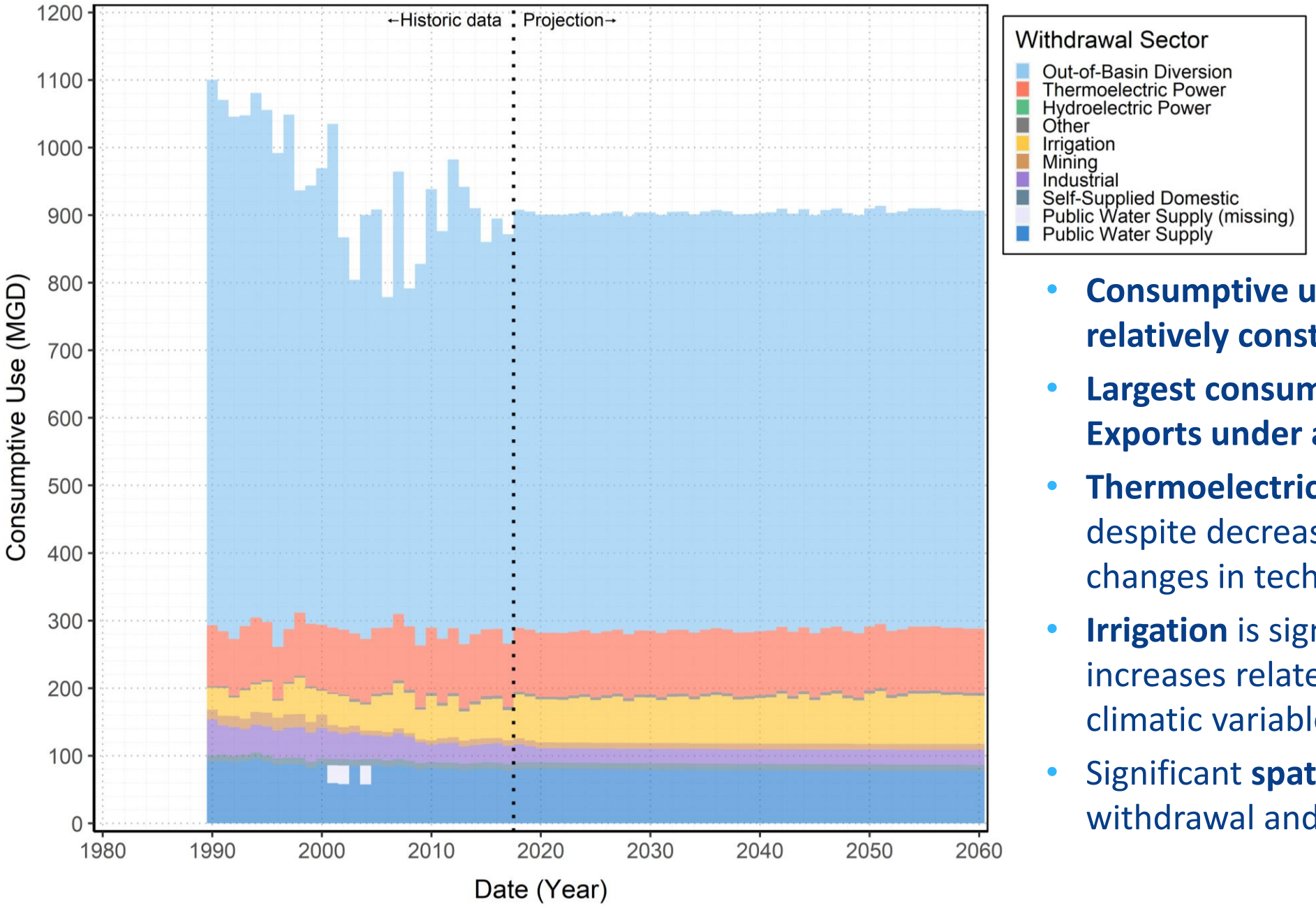
Historic and projected consumptive use in the Delaware River Basin



- **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

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5. Water-Energy Nexus

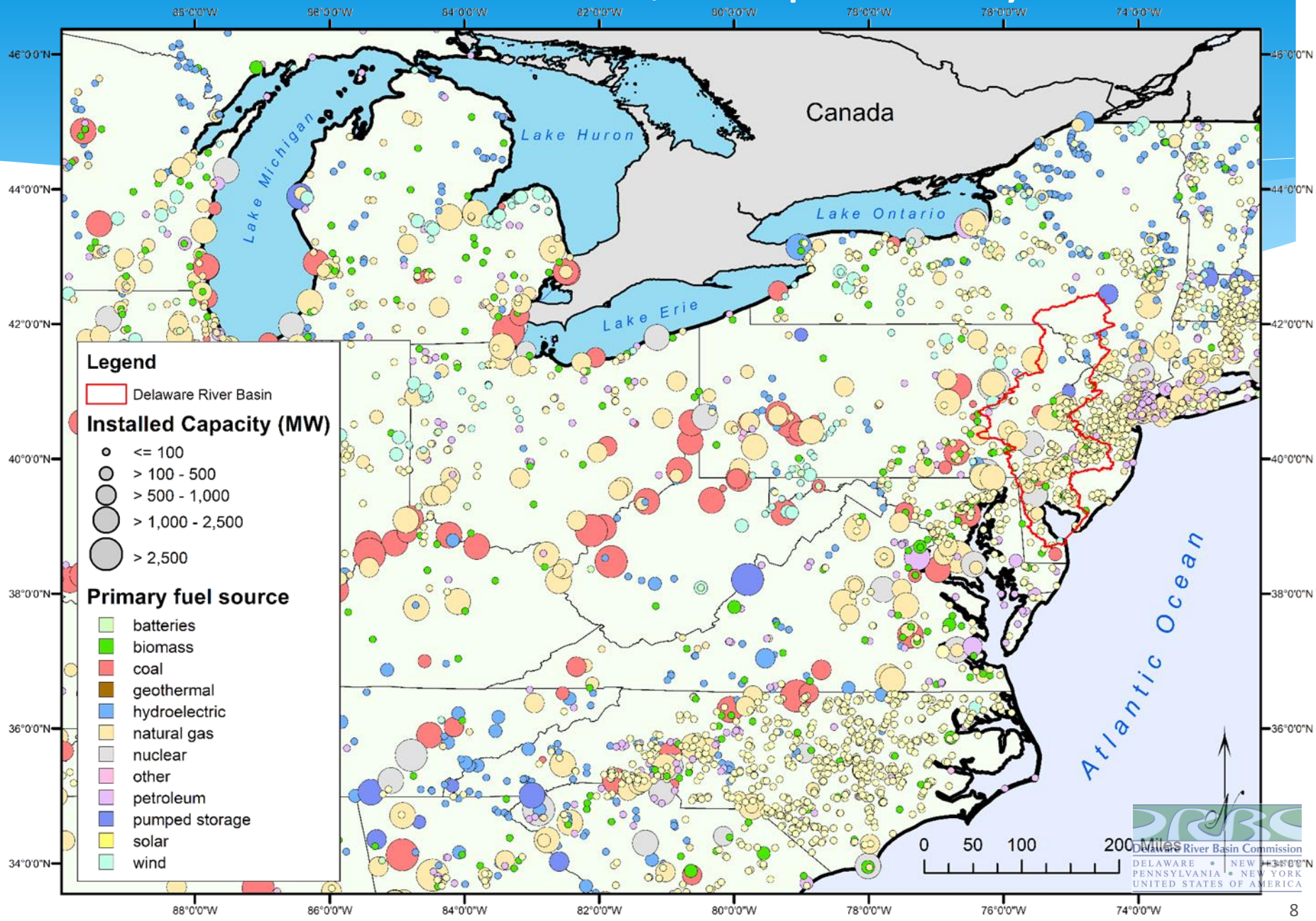
LGS by the Nuclear Regulatory Commission

Context: power in the Delaware River Basin, comparatively

Data sources:
EIA: *PowerPlants_US_202004.shp*
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

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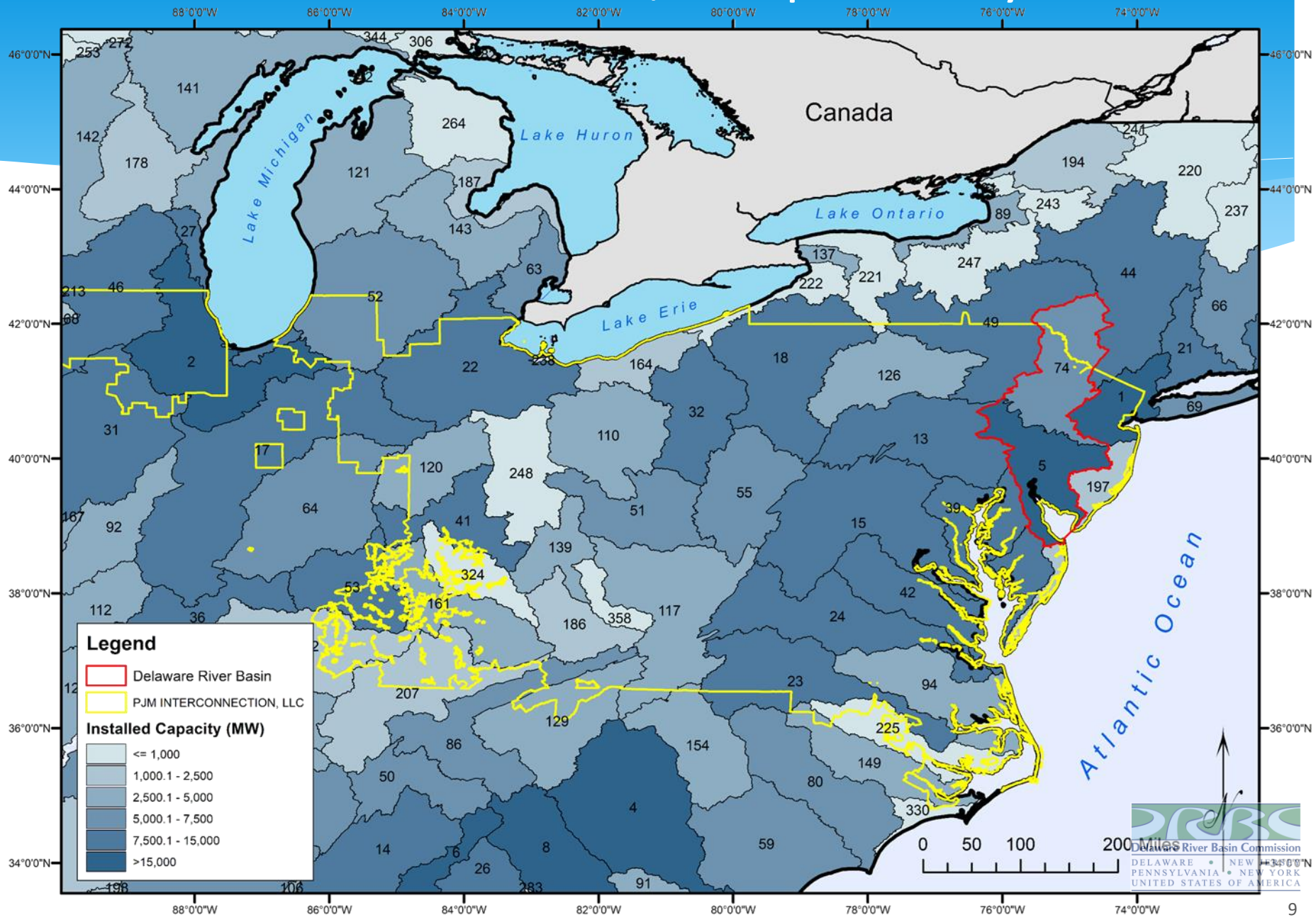
https://www.eia.gov/maps/layer_info-m.php

USGS: *WBD_National_GDB.gdb*
http://prd-tnm.s3-website-us-west-2.amazonaws.com/?prefix=StagedProducts/Hydrography/WBD/National/GDB/

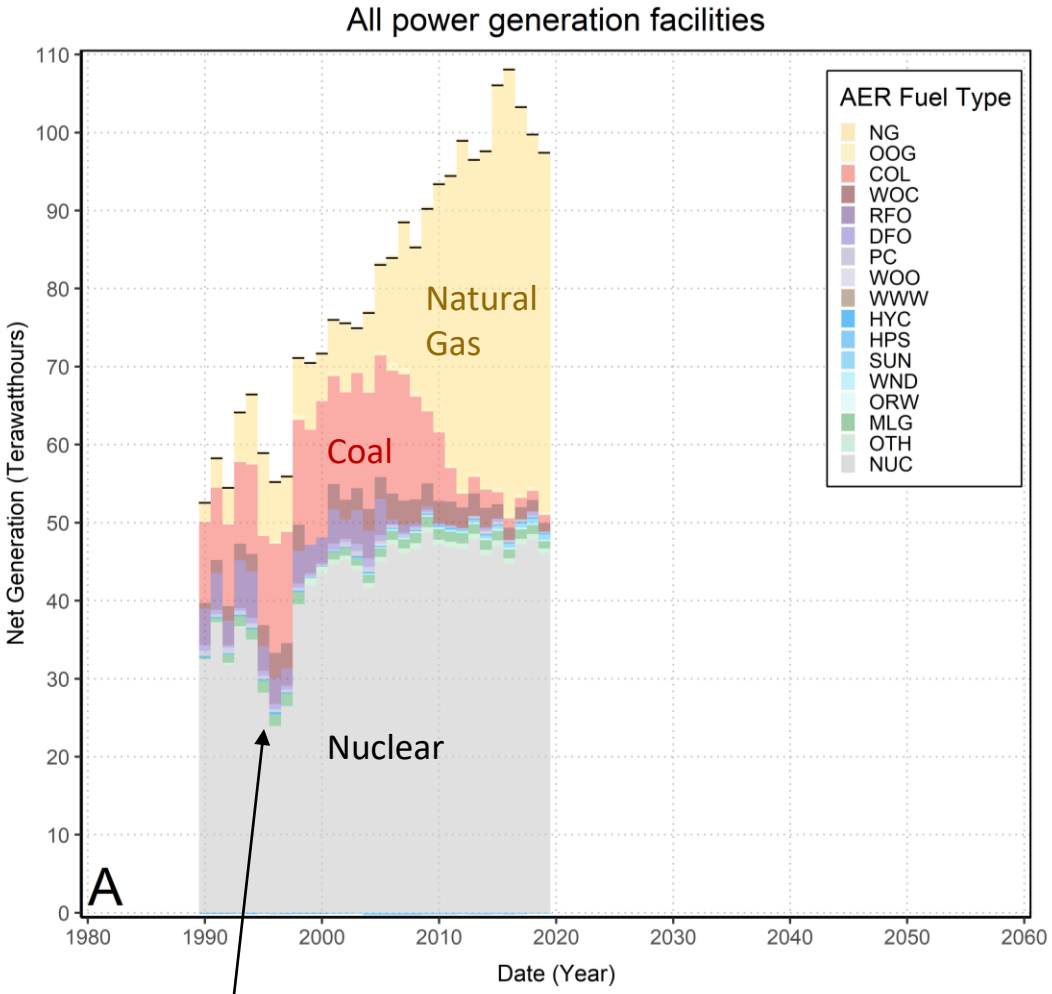
Some notes:

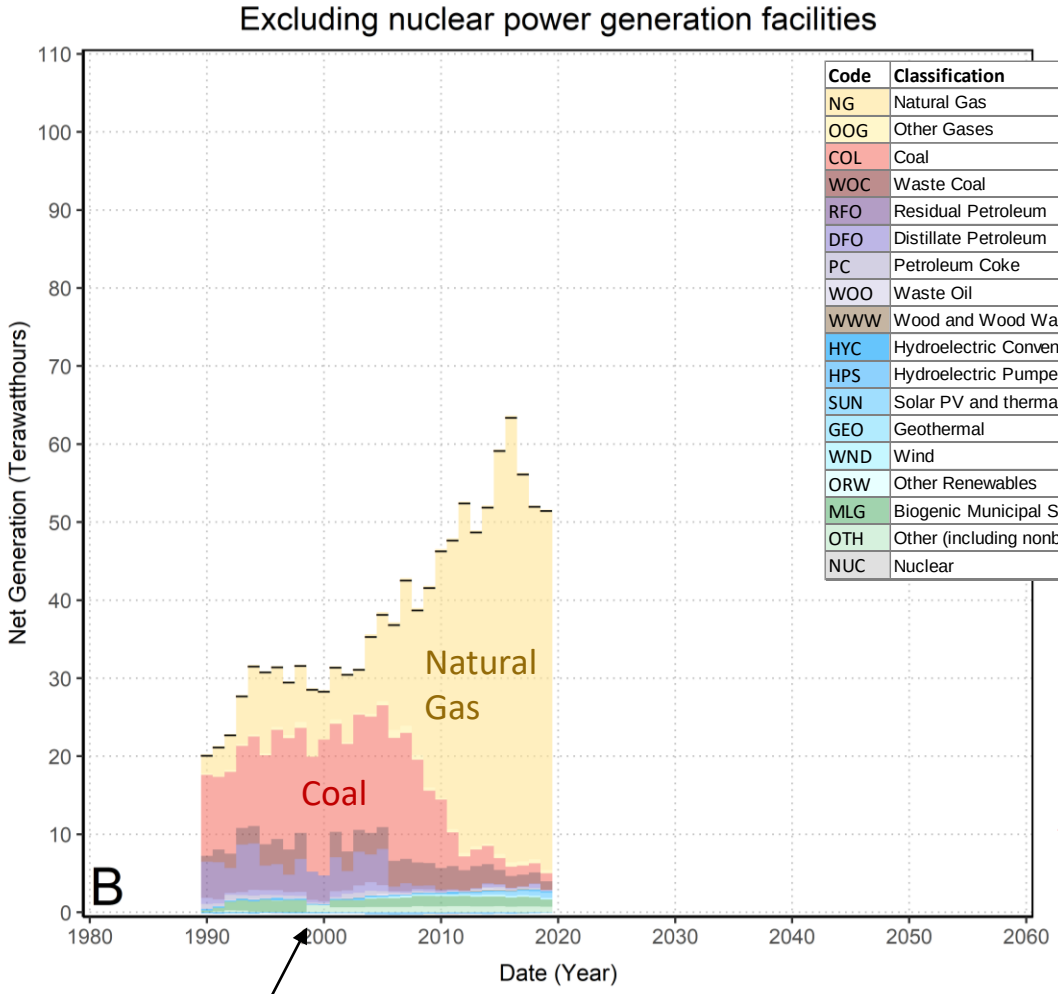
- Aggregate the installed capacity by HUC-6 code.
- 388 HUC-6 codes
  (excludes CN, GU, PR, MX, VI)
- 360 have installed capacity
- (020402) LDRW = 5th / 360
- (020401) UDRW = 74th / 360

Power in the DRB is comparably significant.



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





Code	Classification
NG	Natural Gas
OOG	Other Gases
COL	Coal
WOC	Waste Coal
RFO	Residual Petroleum
DFO	Distillate Petroleum
PC	Petroleum Coke
WOO	Waste Oil
WWW	Wood and Wood Waste
HYC	Hydroelectric Conventional
HPS	Hydroelectric Pumped Storage
SUN	Solar PV and thermal
GEO	Geothermal
WND	Wind
ORW	Other Renewables
MLG	Biogenic Municipal Solid Waste and Landfill Gas
OTH	Other (including nonbiogenic MSW)
NUC	Nuclear

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"

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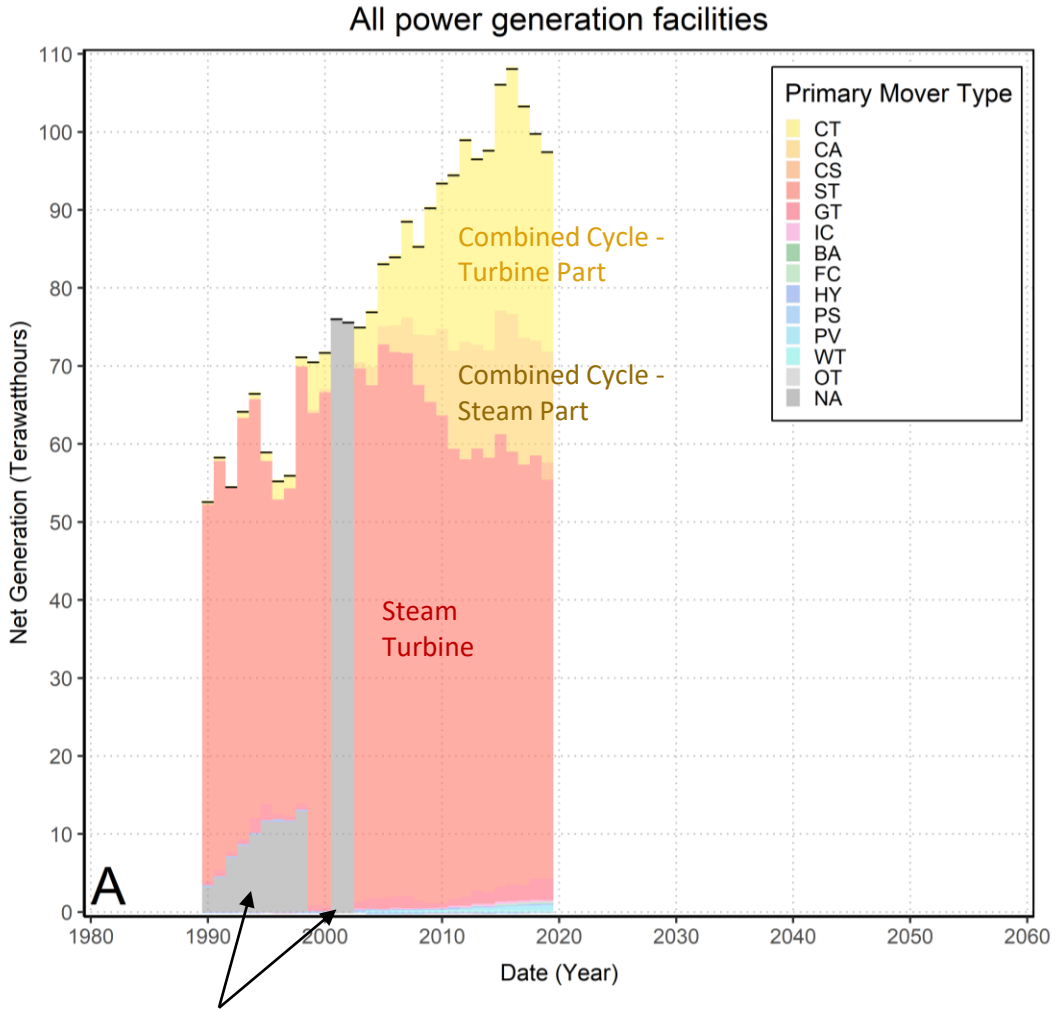
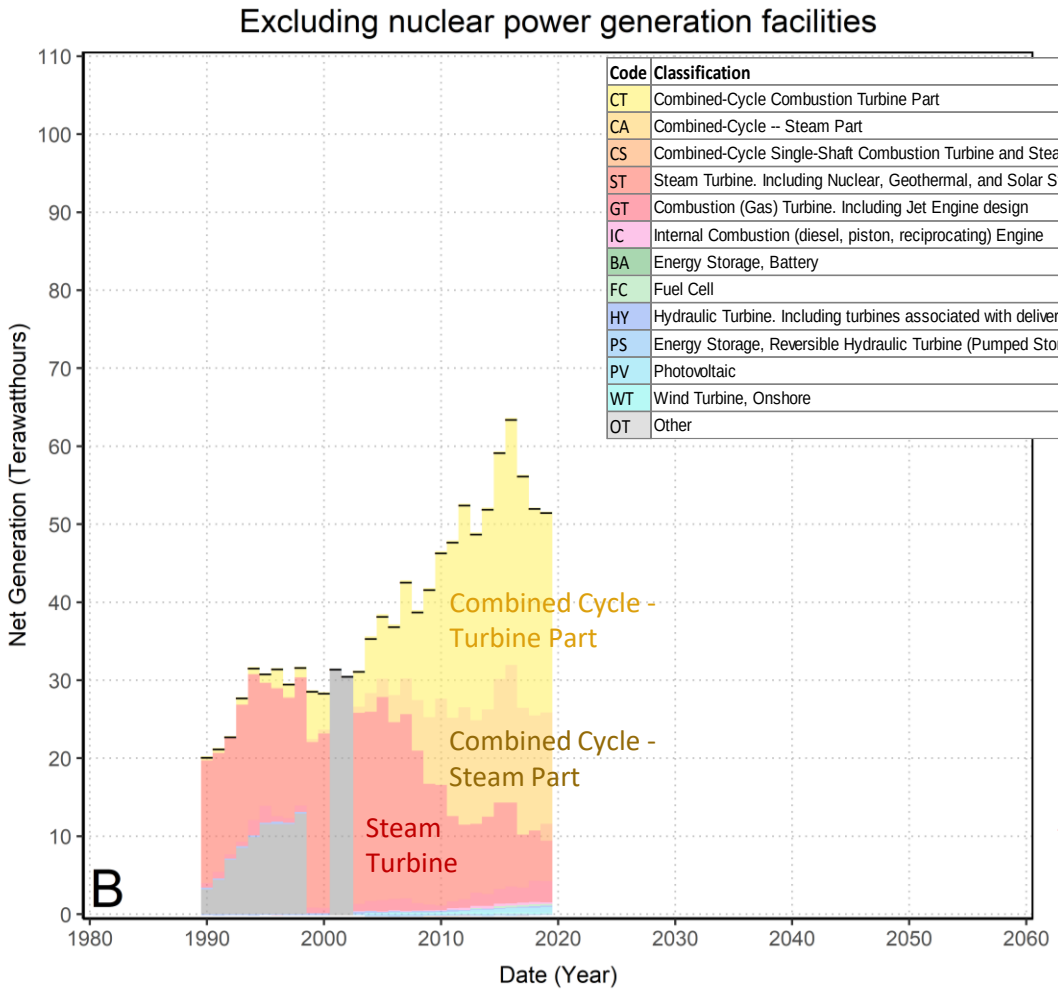
Historic power data: DRB-facilities net gen. (primary mover)



Data gaps due to unavailable information reported to EIA forms



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.

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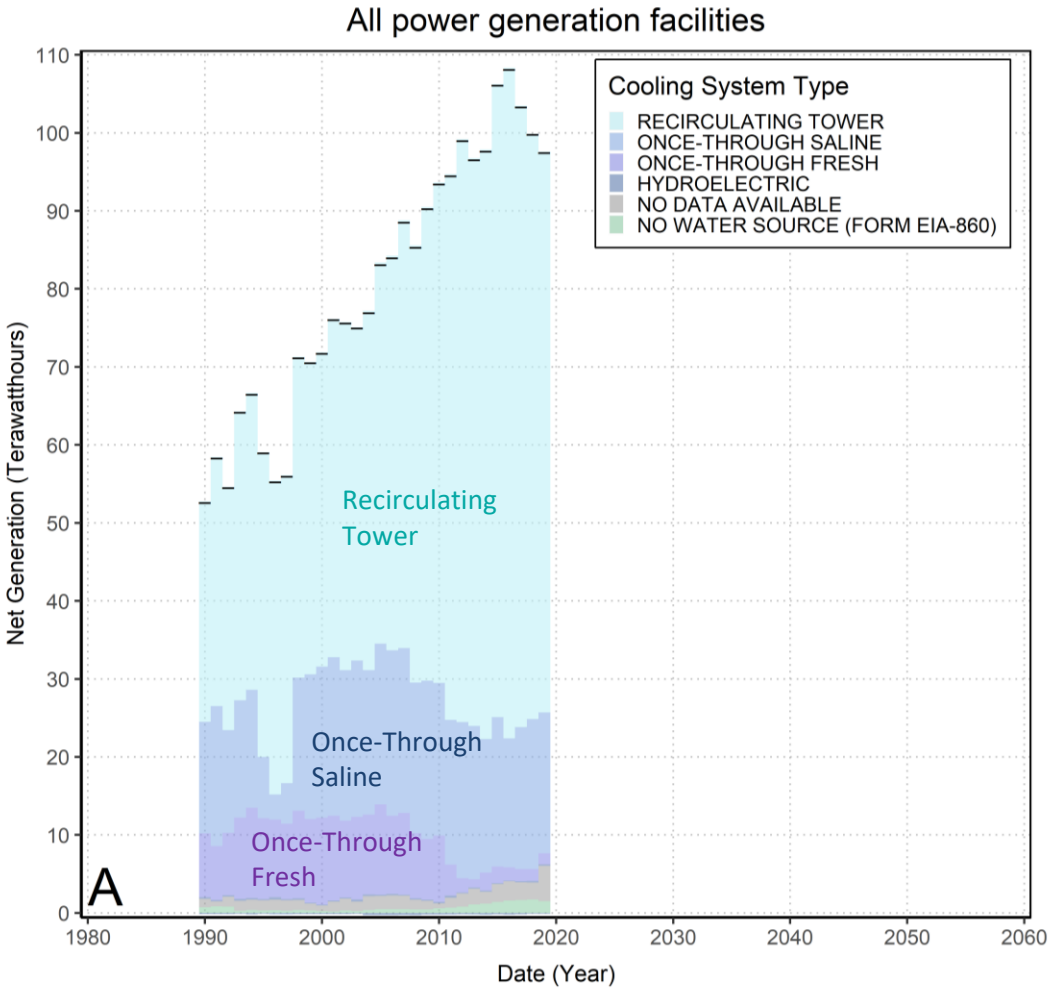
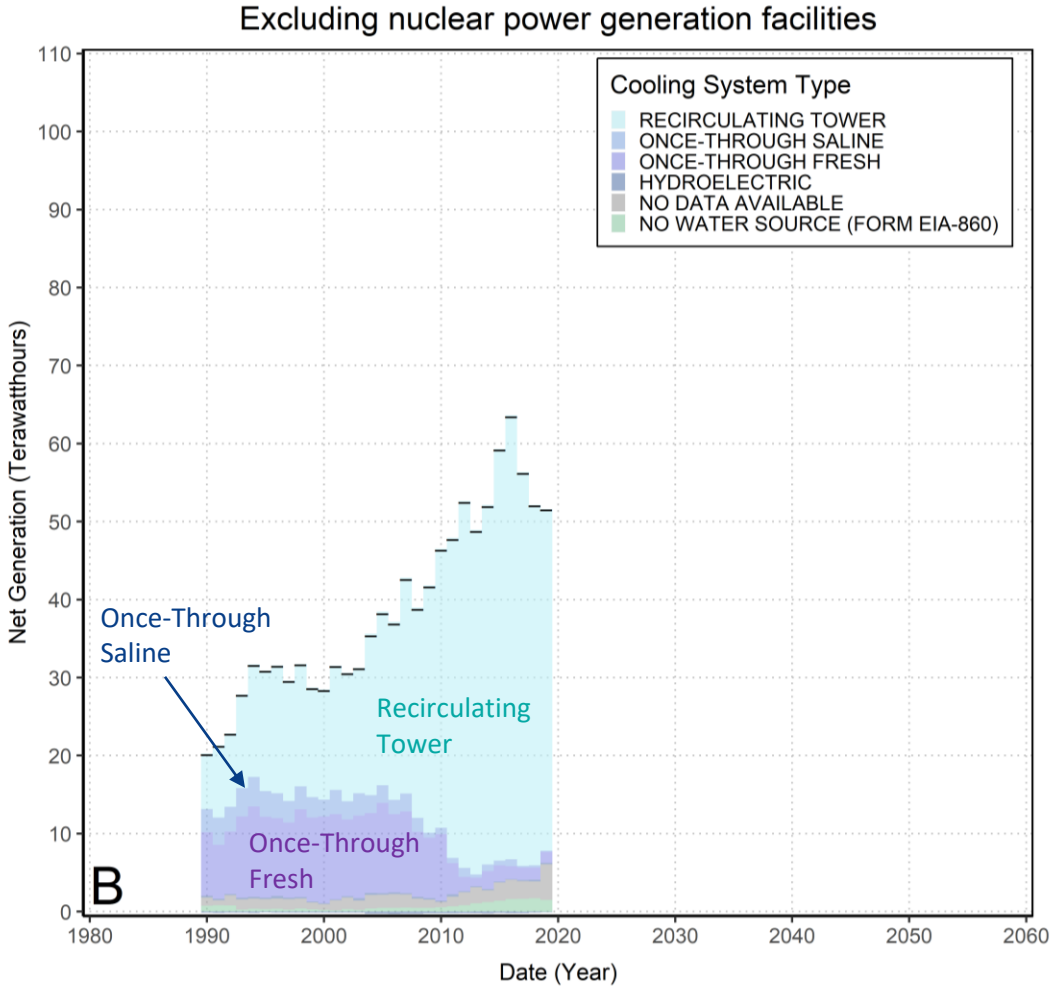
Historic power data: DRB-facilities net gen. (cooling system)





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

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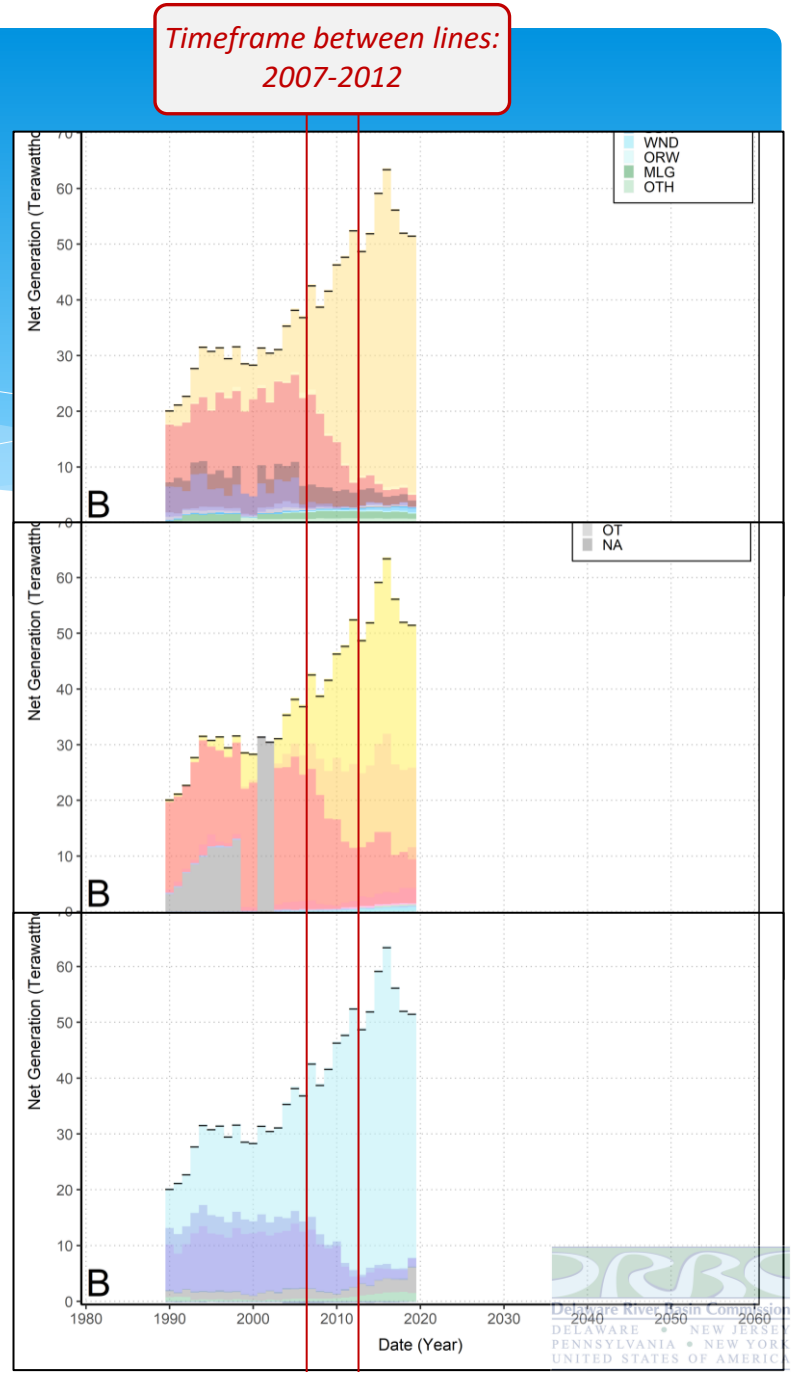
Notes on historic DRB net generation

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 stream 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%

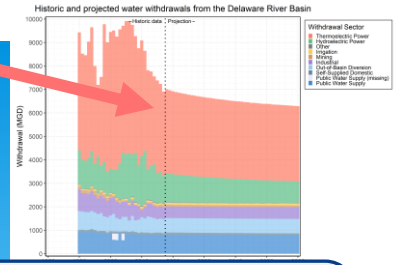


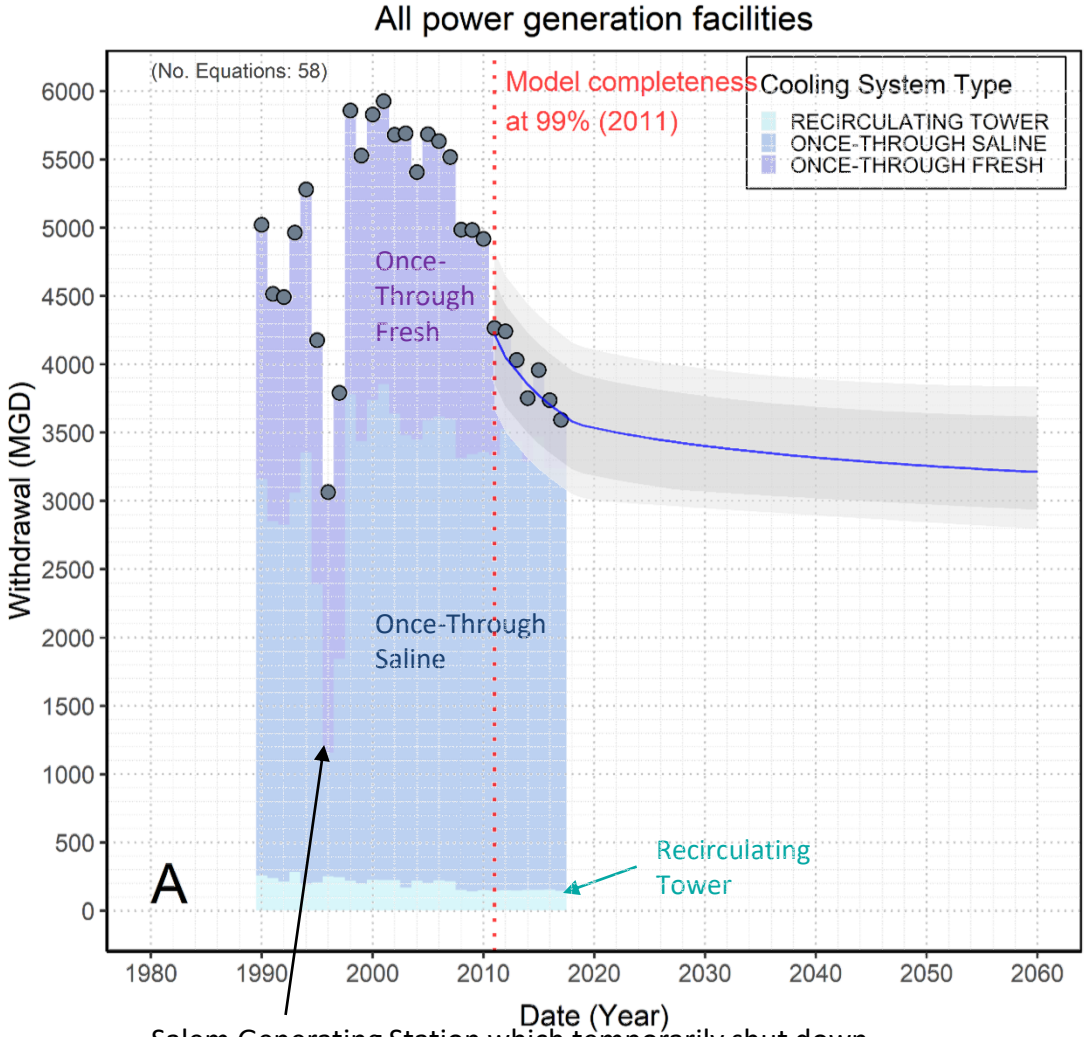
Non-nuclear facilities

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)

Thermoelectric 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)

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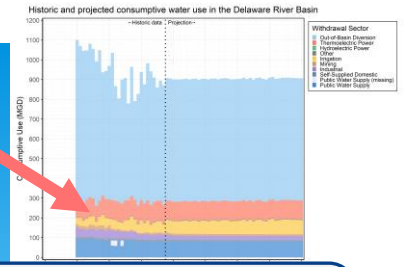
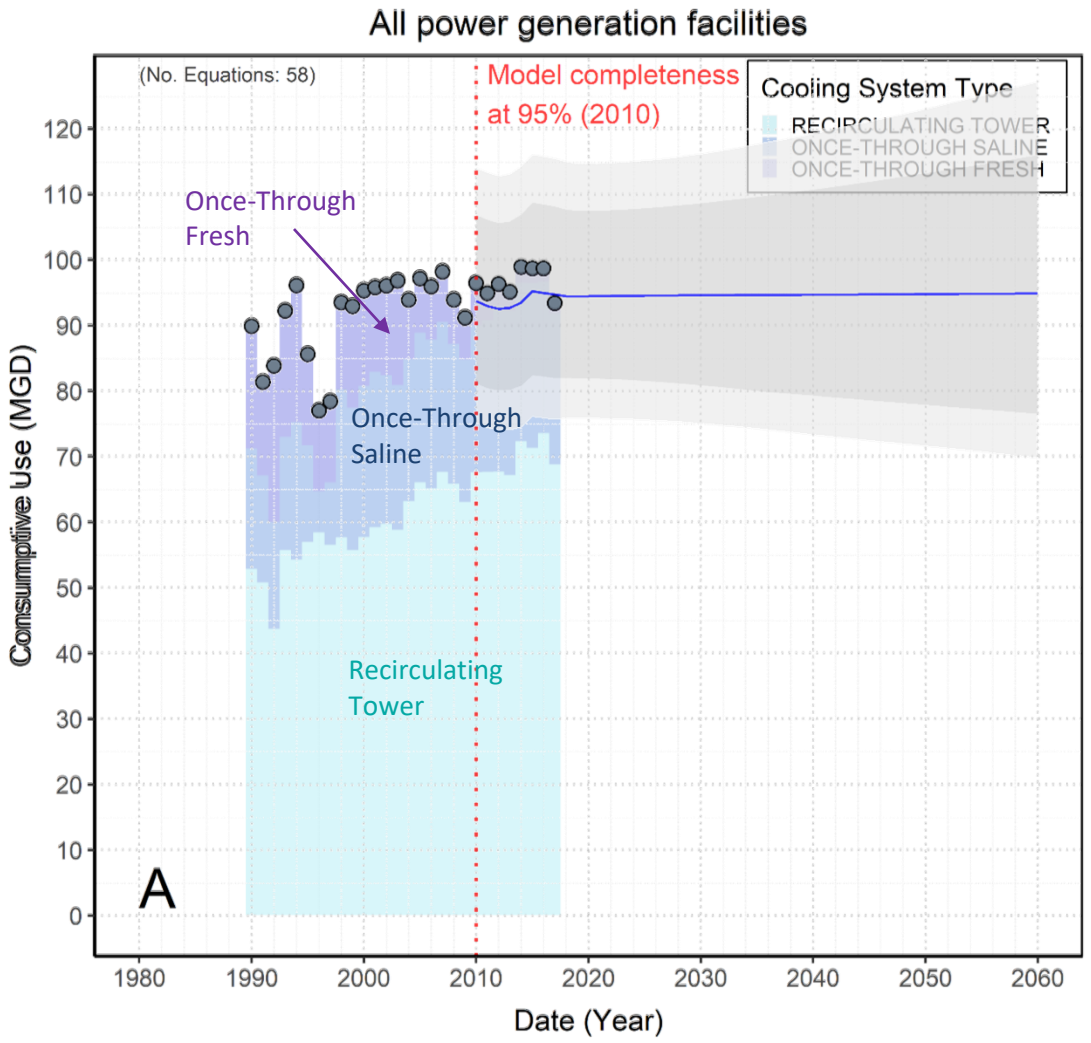
Thermoelectric: all facilities (consumptive use)

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.

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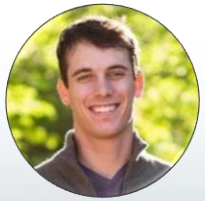
6. Questions



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Cape Henlopen, Delaware.
Credit: Delaware State Parks
https://destateparks.com/Beaches/CapeHenlopen

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