An Examination of Future Power Generation Scenarios and Water Resource Impacts

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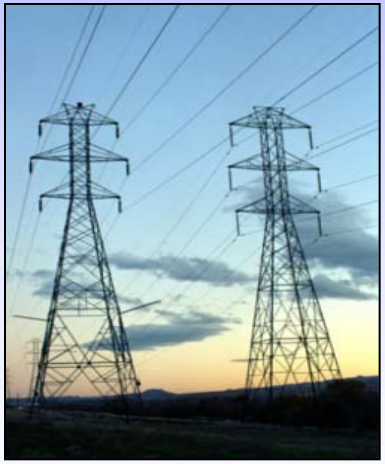

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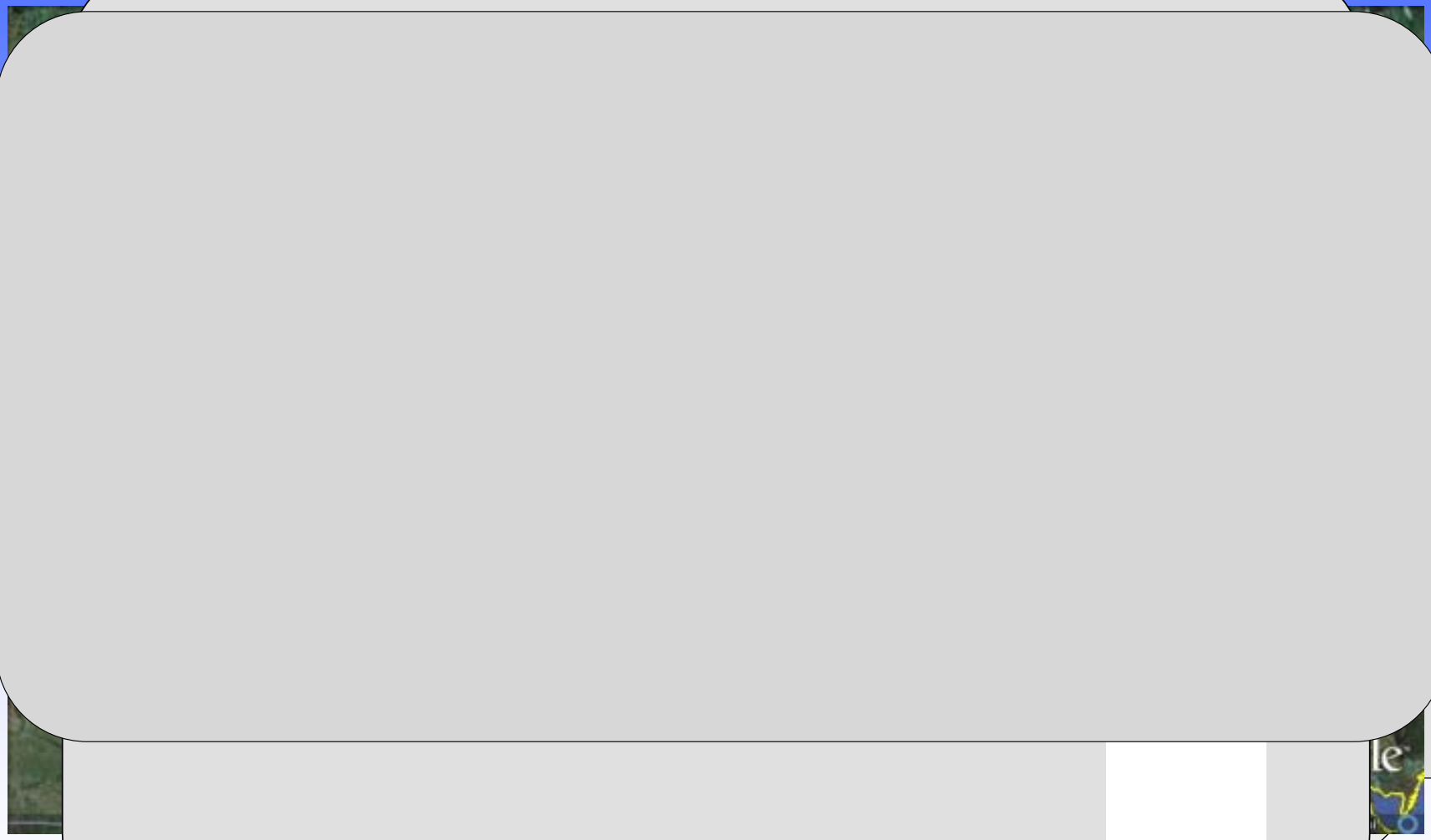
Objectives



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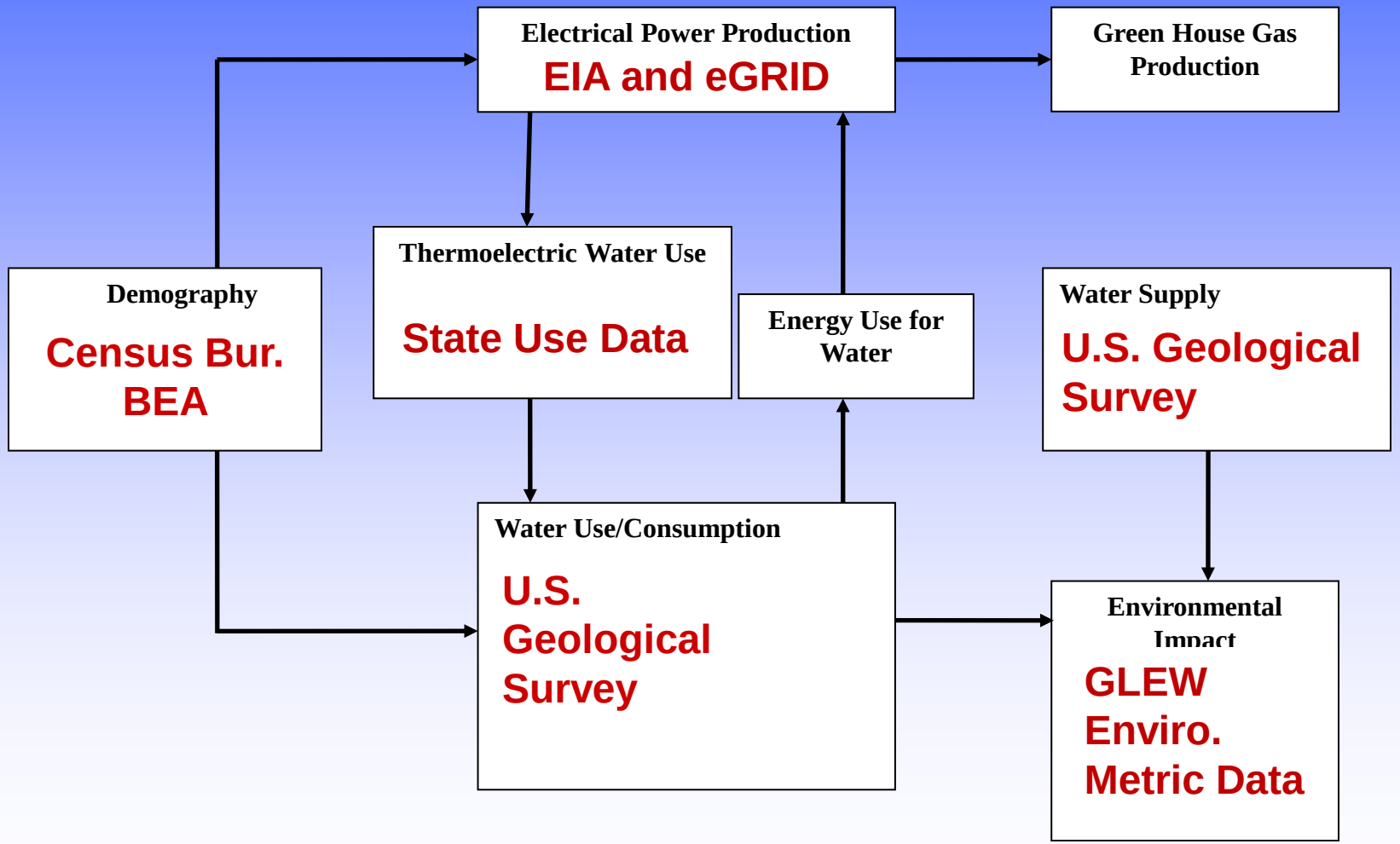
General Model Structure



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Power Generation Analysis

- Data source is EIA/eGRID, 2007 fleet
- Simulated at the power plant level with 583 individual plants modeled (Great Lakes Basin)
- Plants distinguished by
  - Fuel type,
  - Utility vs. non-utility,
  - Boiler type,
  - Build date,
  - Installed capacity,
  - Geographic location,
  - Annual power output,
  - Cooling type.
- Water use data based on eGRID reports, state reported data and rectification with USGS county-level thermoelectric water use data base

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Power Generation Analysis

- Future electricity demand utilizes EIA forecasts to 2035.
- Demand is modeled according to 5 Electricity Market Module regions that intersect the Great Lakes Basin.
- Future generation in each basin is assumed to follow similar ratio at that in 2005
- “Planned” power plants are taken from EIA
- Future mix of remaining fleet defined by analyst
- Plants sited according to current ratio of watershed to EMMR production in 2005

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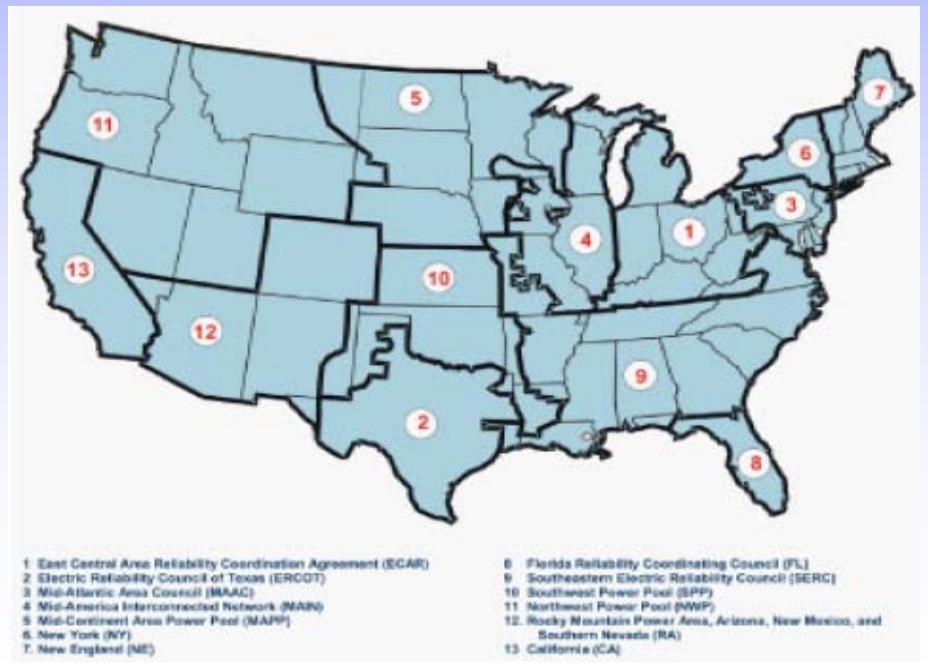
Model Domain



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Water Use Analysis

- Water use data taken from U.S. Geological Survey's "Water Use in the United States"
- Data were collected at five year intervals from 1985-2005
- Data are available at the national, state, county and watershed levels
- For purposes of analysis data are disaggregated by:
  - Sector {municipal, industrial, thermoelectric, mining, livestock, and agriculture}
  - Source {groundwater, surface water, other}
  - Distinguish between use and consumption

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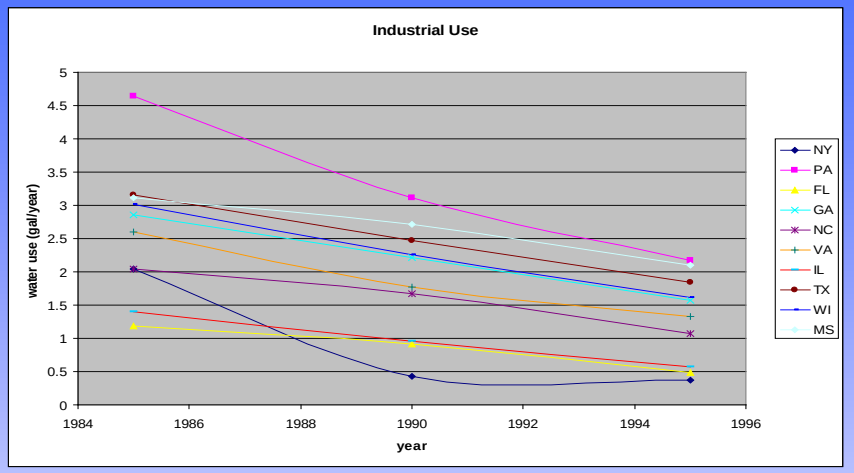
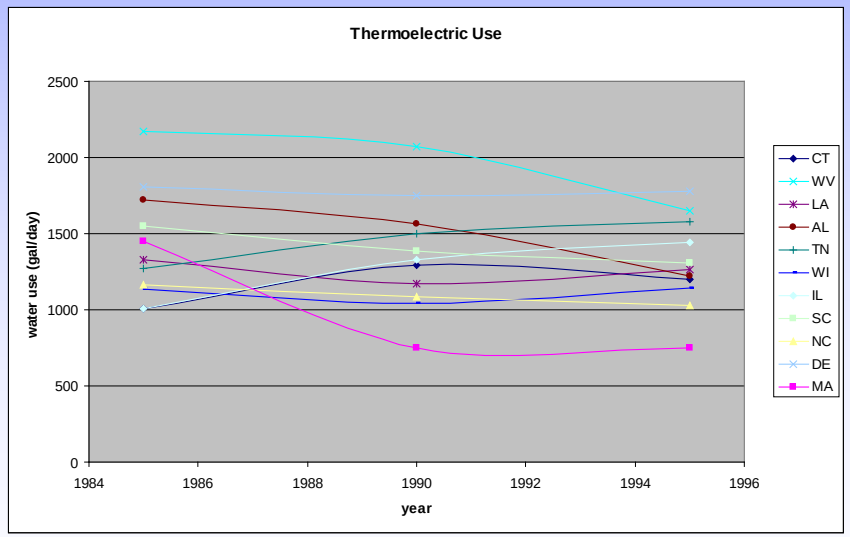
Water Use Analysis

- Future water use projections based on historical trends
- Trends analyzed through simple linear regression over the available 20 years of data (10 years for consumptive use)
- Trends explored in terms of:
  - Direct water use
  - Per capita use
  - Economic intensity





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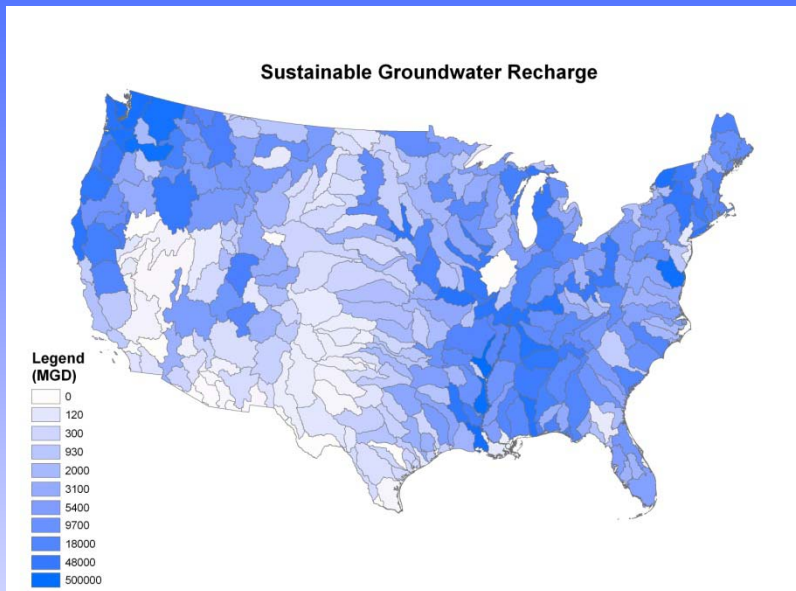
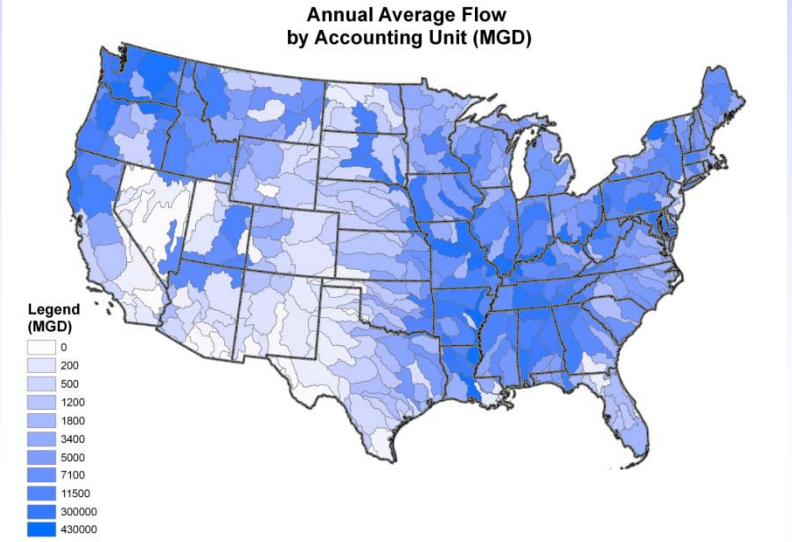
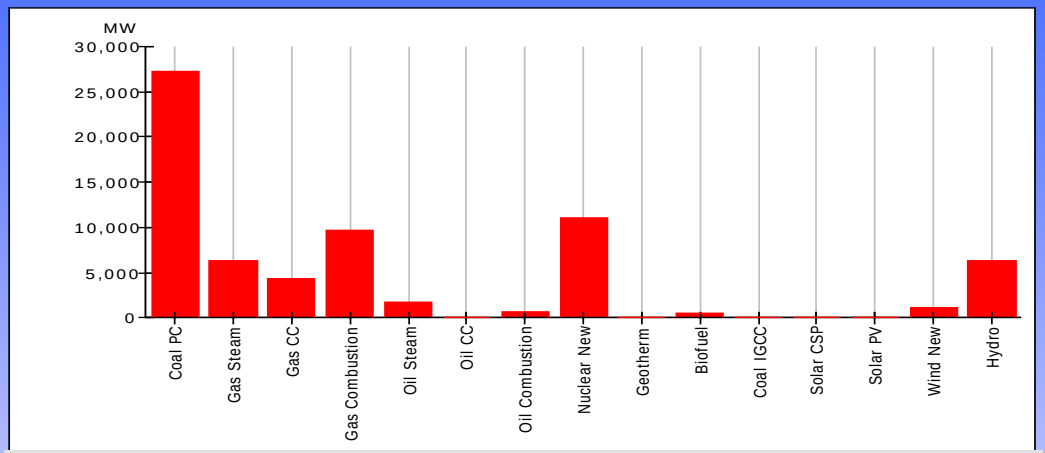
Dynamic Supply Indicators

- Utilize historical stream gauging data from the USGS (cumulative distributions)
- Data used at the 8-digit HUC or 107 watersheds
- August average flows are from the Large Basin Runoff Model (Croley, 2002)





Basin in 2007



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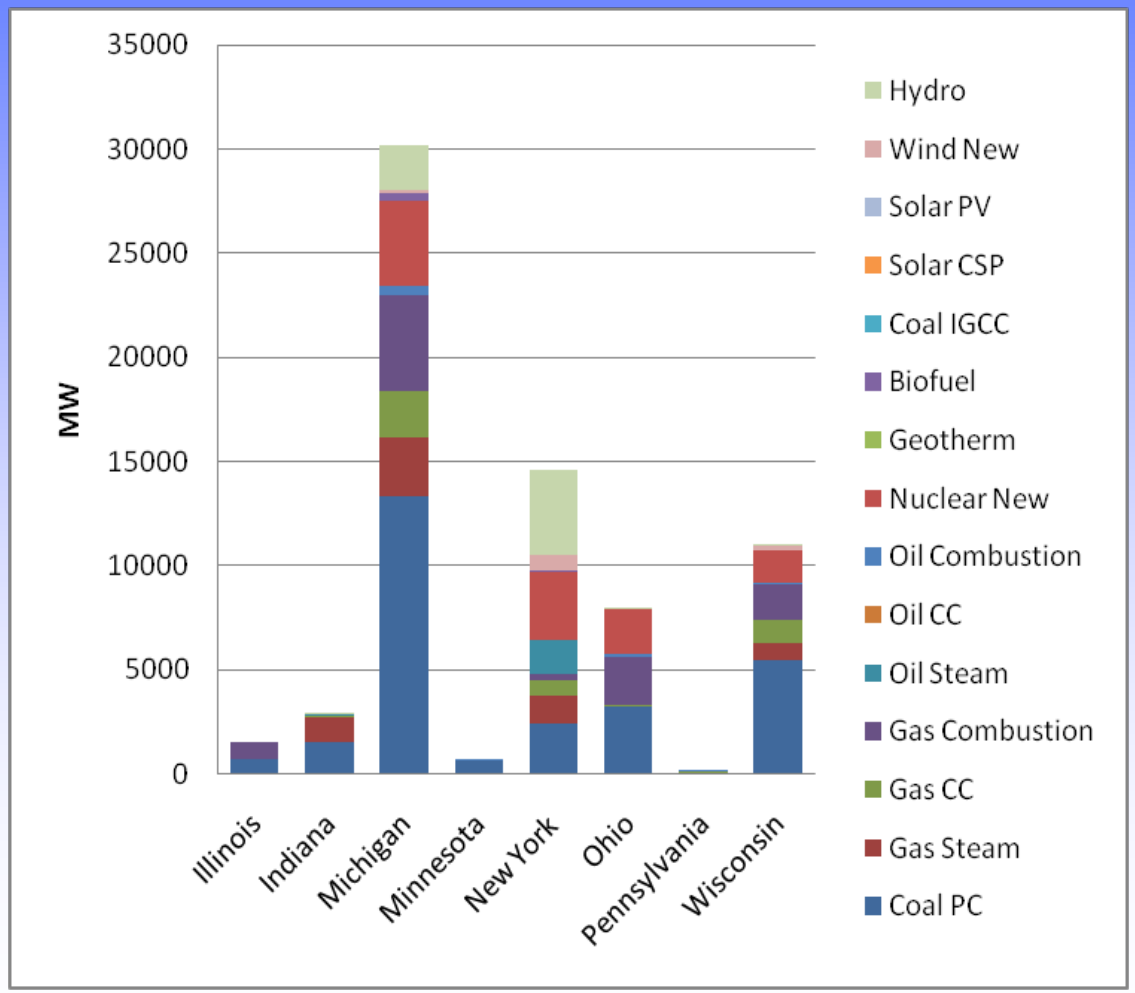
Plant Fuel Type by State 2007



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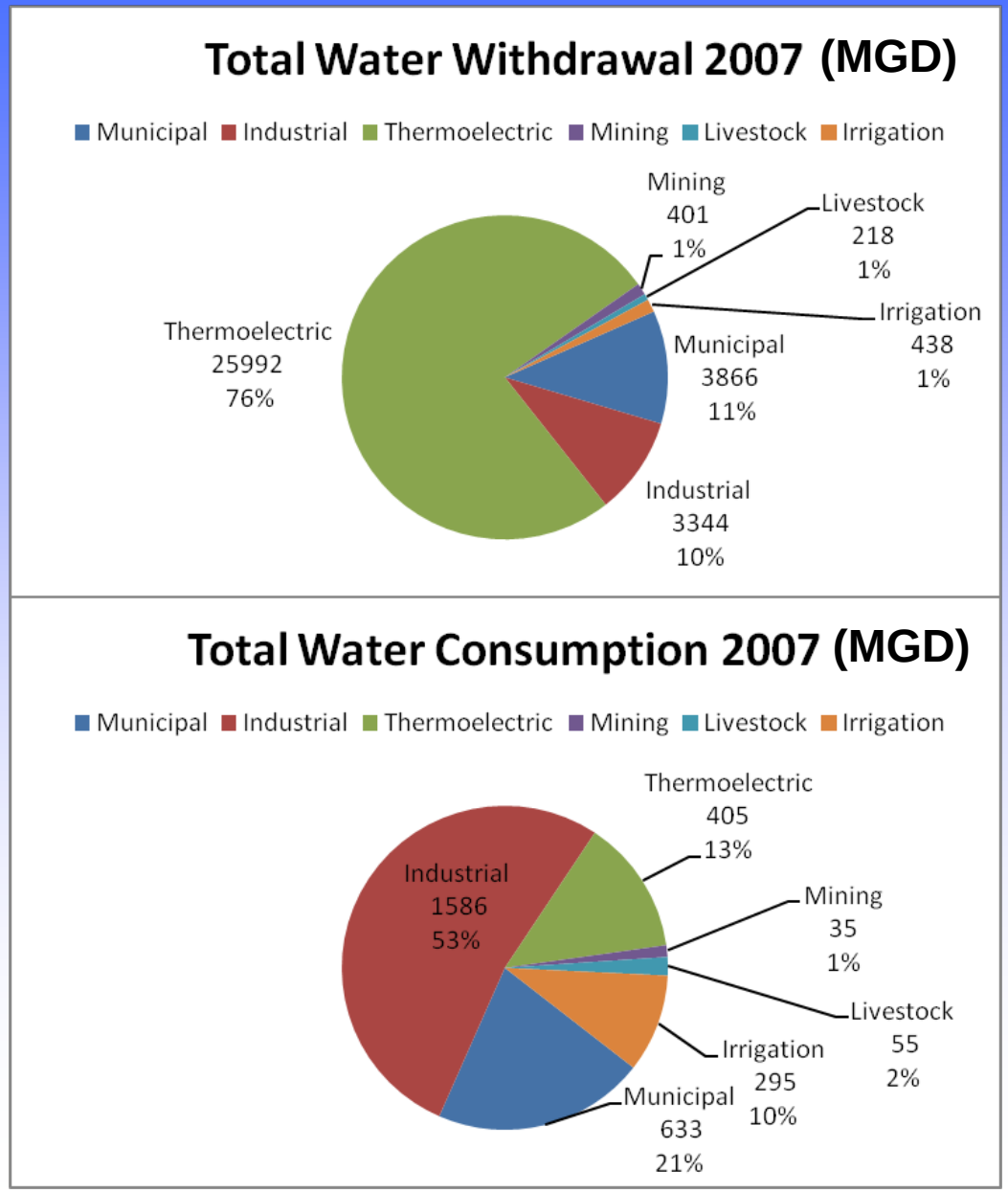

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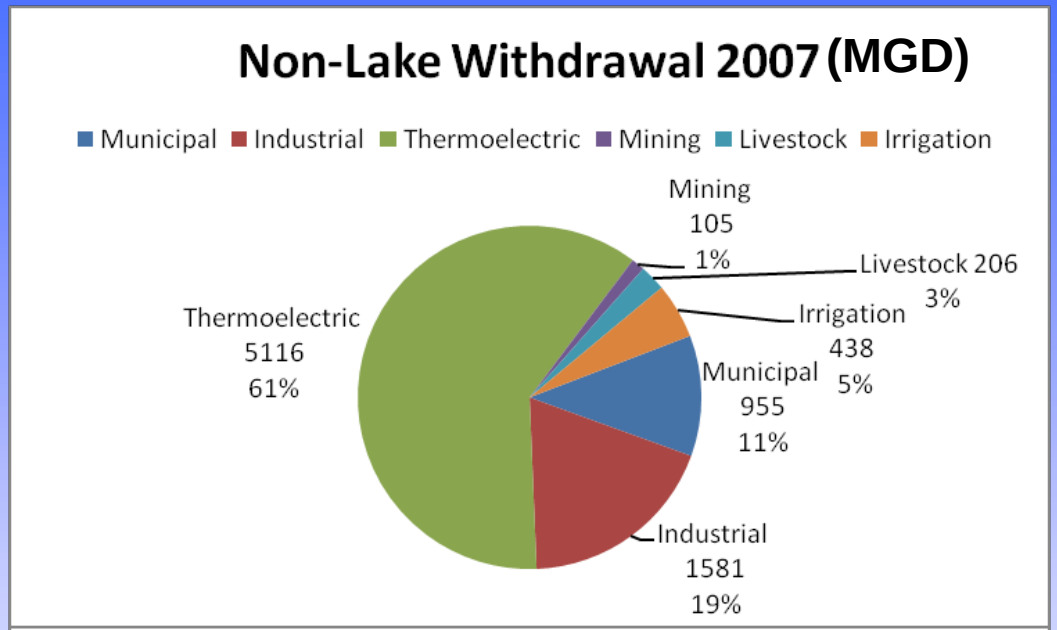
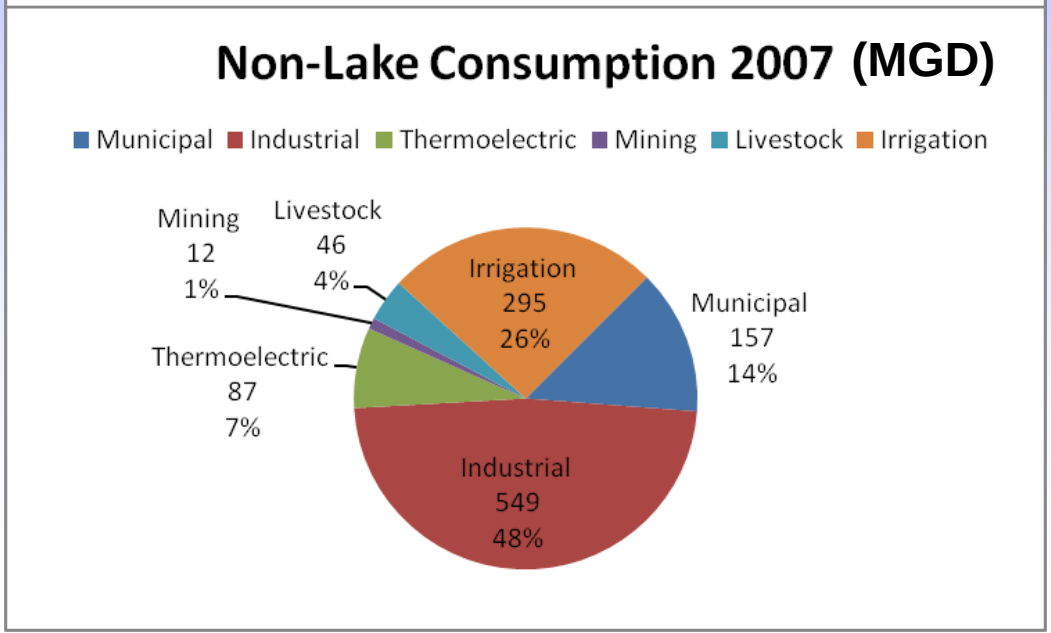
Basin in 2007





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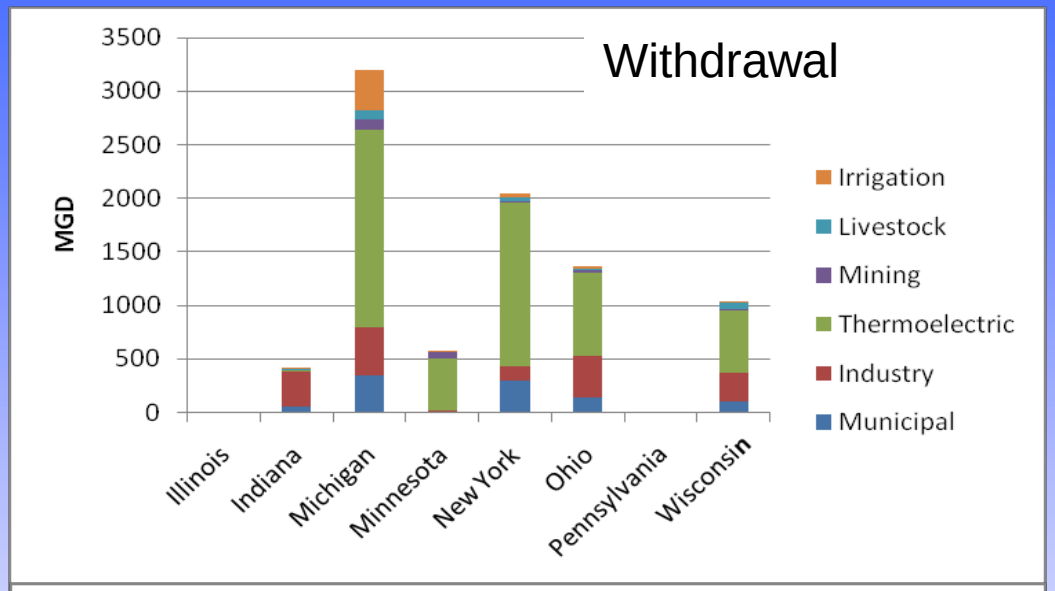
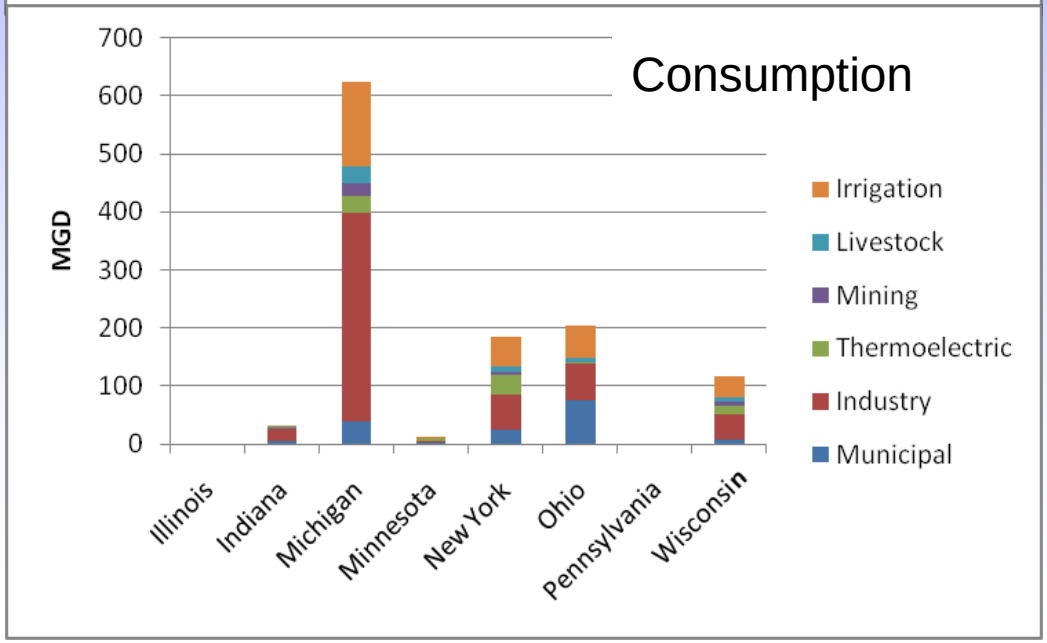
State Water Use 2007





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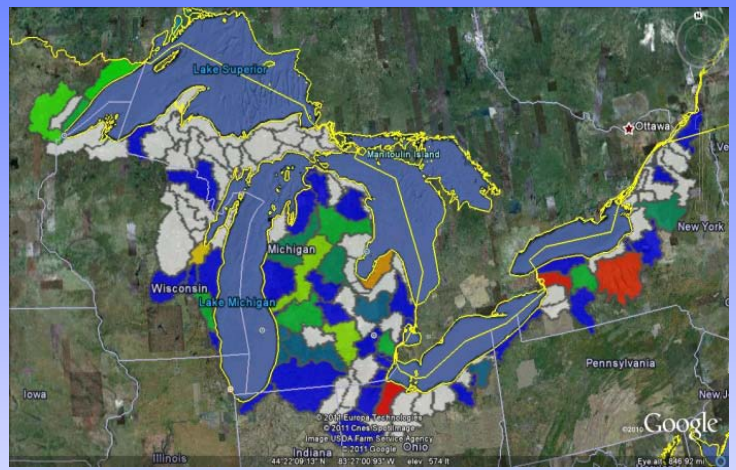
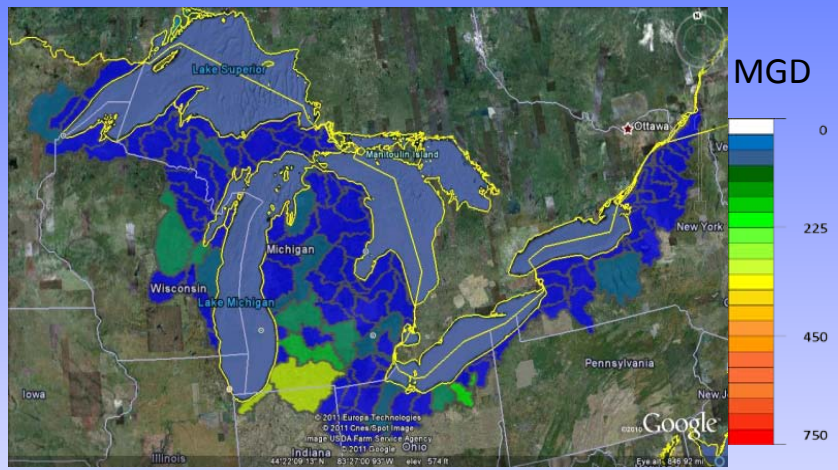
Water Use by Watershed 2007

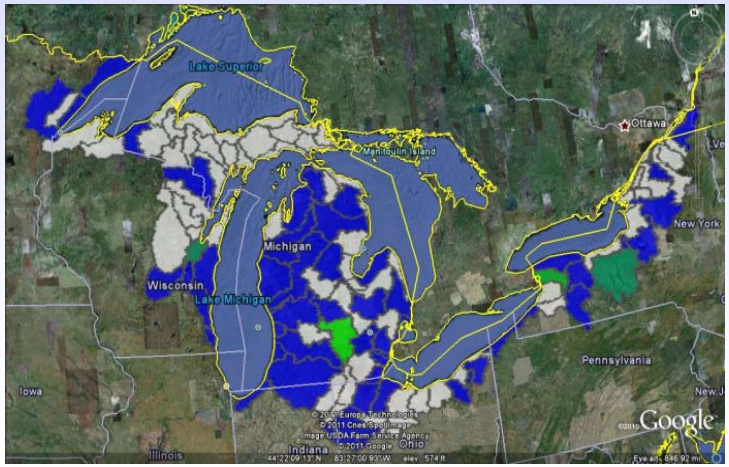
Thermoelectric Withdrawals



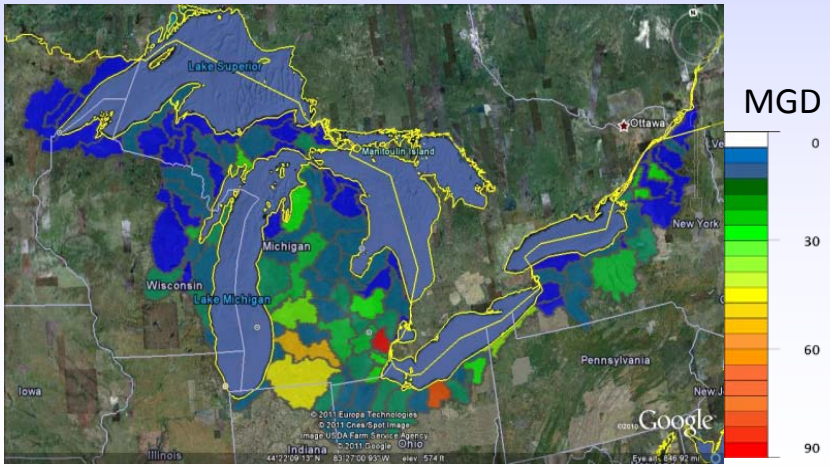
Non-Thermoelectric Withdrawal



Thermoelectric Consumption



Non-thermoelectric Consumption



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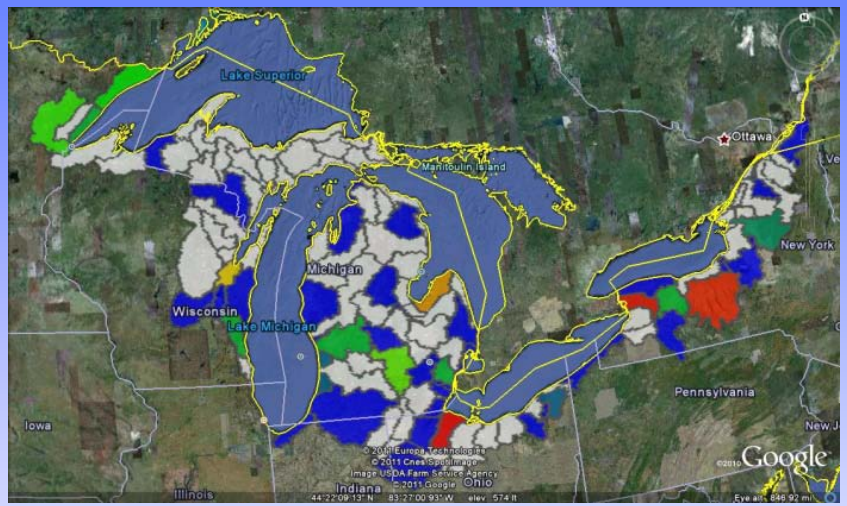
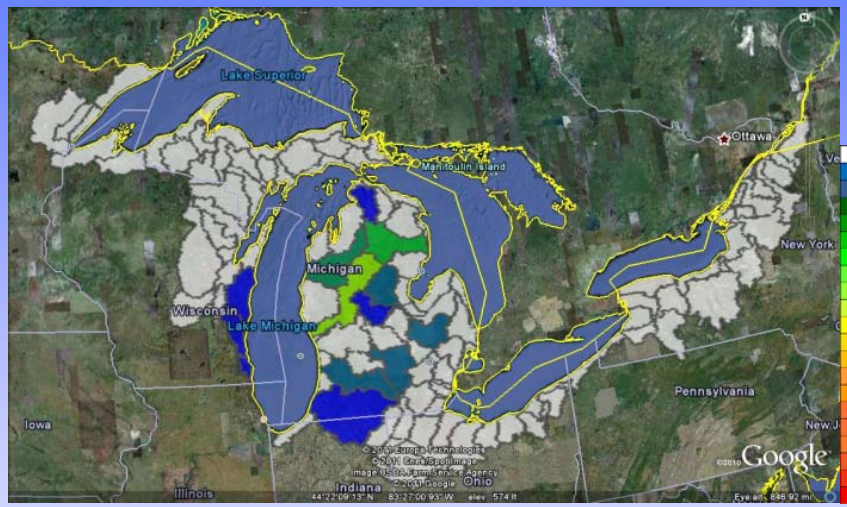
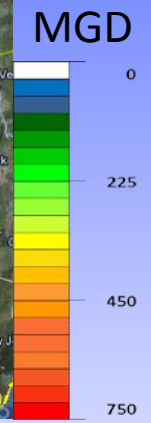
Thermoelectric Source Water Use 2007

Surface Water Withdrawals

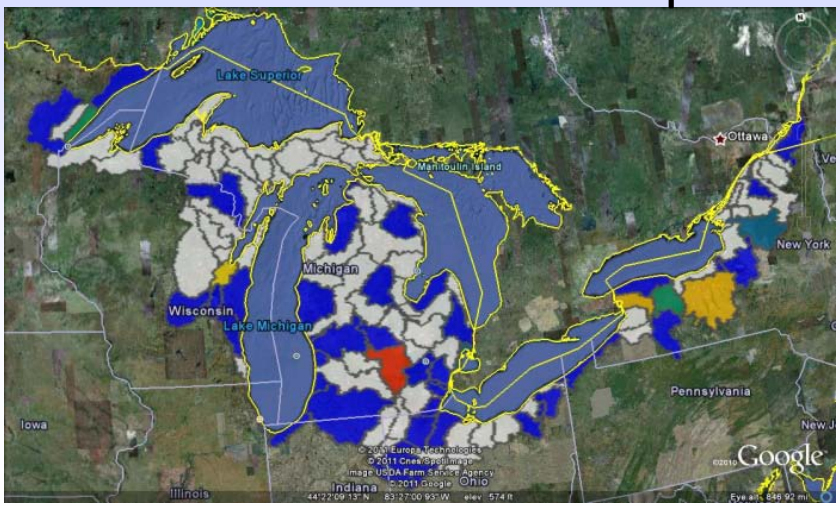


Groundwater Withdrawals

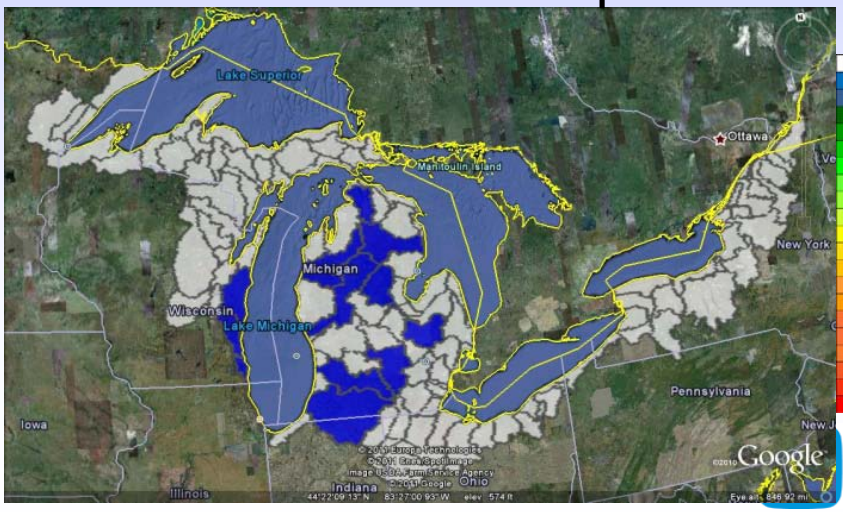


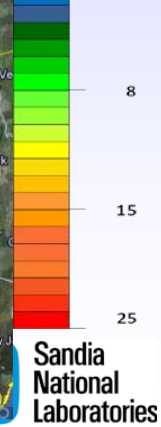


Surface Water Consumption



Groundwater Consumption





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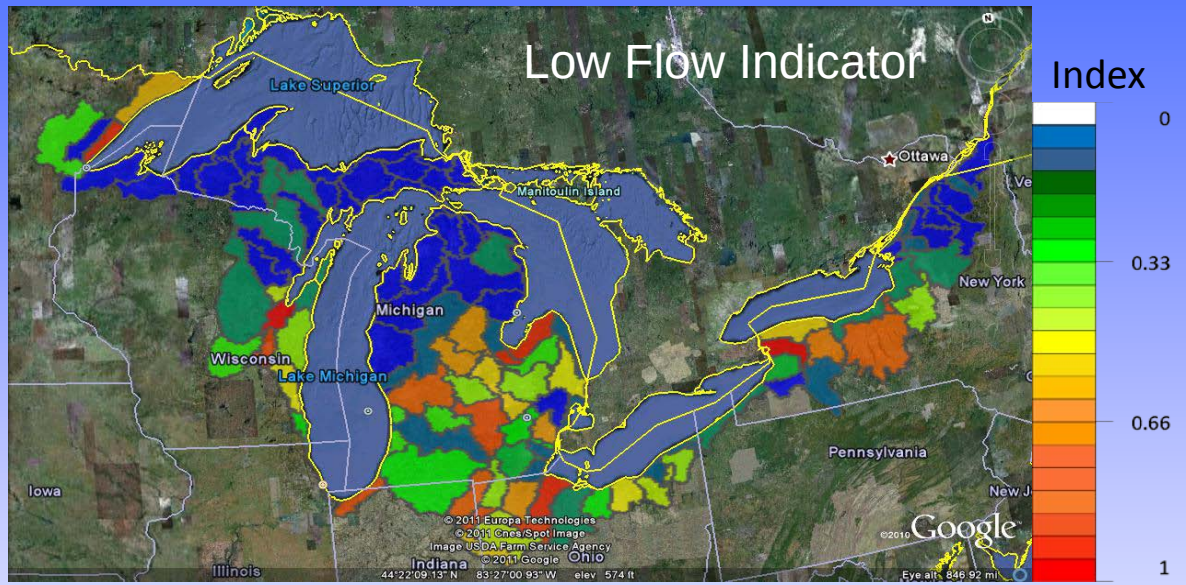
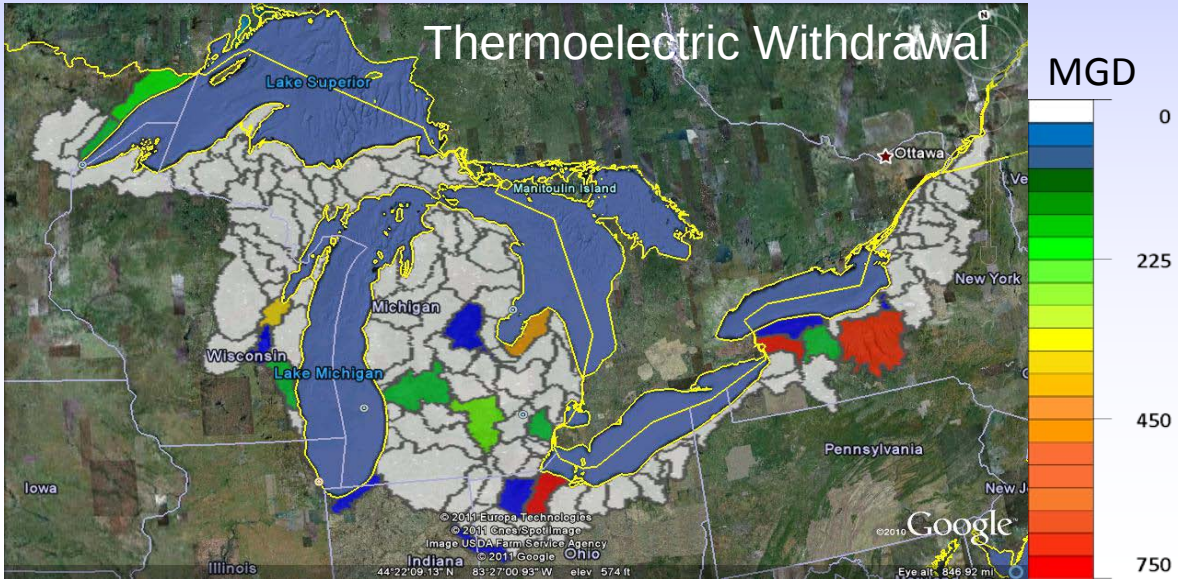
Environmental Quality 2007





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Key Finding

- Water withdrawal and consumption metrics for thermoelectric power generation are significant in the Great Lakes Watershed. The thermoelectric sector accounts for 76% of the basin's withdrawals and 13% of the consumption. Most of this water use comes directly from the Great Lakes, accounting for 81% of all withdrawals from the Great Lakes.

Scenario Analysis

- Business as Usual (BAU)
  - Energy/Water demand follow EIA projections and Census Bureau/BER population and GDP projections
  - New power plants adopt:
    - Current fuel mix,
    - Current mix of cooling technology,
    - Current source water mix, and
    - Siting based on 2005 watershed/EMMR production ratios

Scenario Analysis

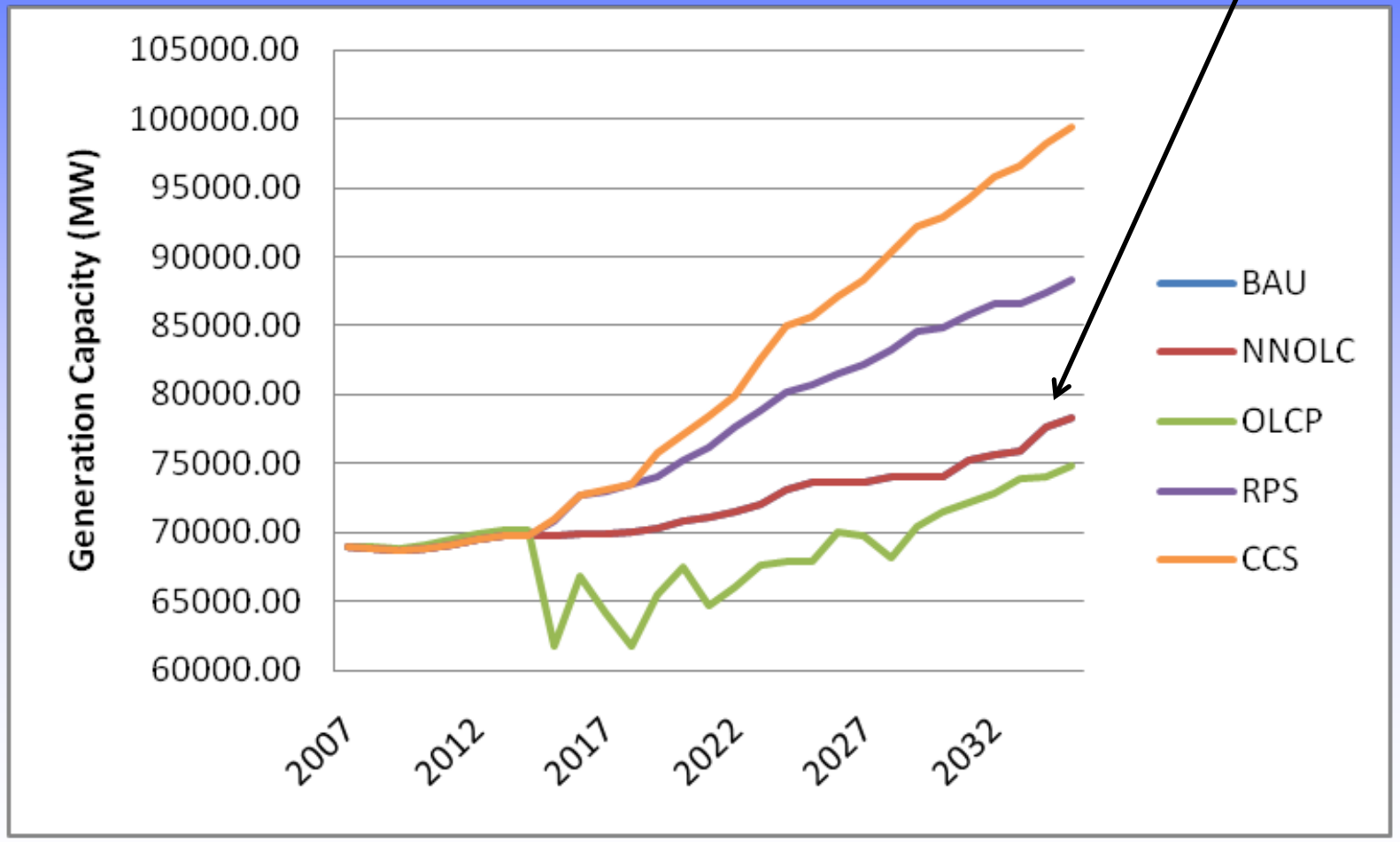
- No New Open Loop Cooling (NNOLC)
  - Same assumptions as BAU except
    - No new open loop cooling
    - Water source mix favors tributary/groundwater source
- Open Loop Cooling Prohibited (OLCP)
  - Same assumptions as NNOLC except
    - Existing plants with OLC are converted
    - Plants older than 35 years with capacity factor below 20% are retired

Scenario Analysis

- Renewable Portfolio Standard (RPS)
  - Same assumptions as NNOLC except
    - Assumes higher penetration of renewables
    - 50% wind, 25% biofuel and 25% NGCC
- Carbon Capture and Sequestration
  - Same assumption as RPS except
    - Carbon cap set at 20% of 2007 levels
    - Takes effect in 2015 and with target date of 2030

Electric Capacity

BAU is Coincident with NNOLC



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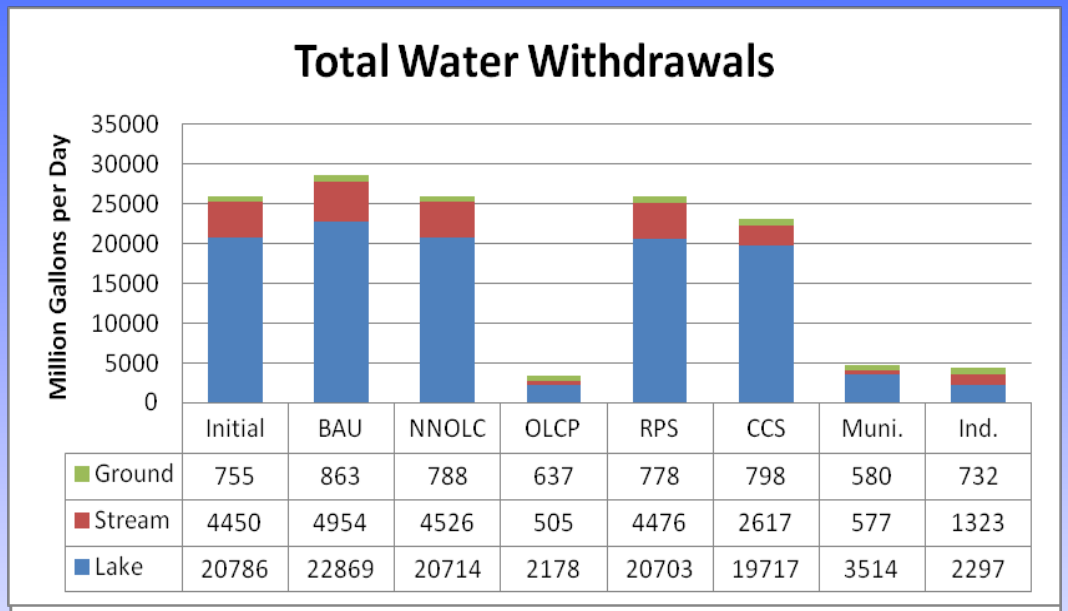
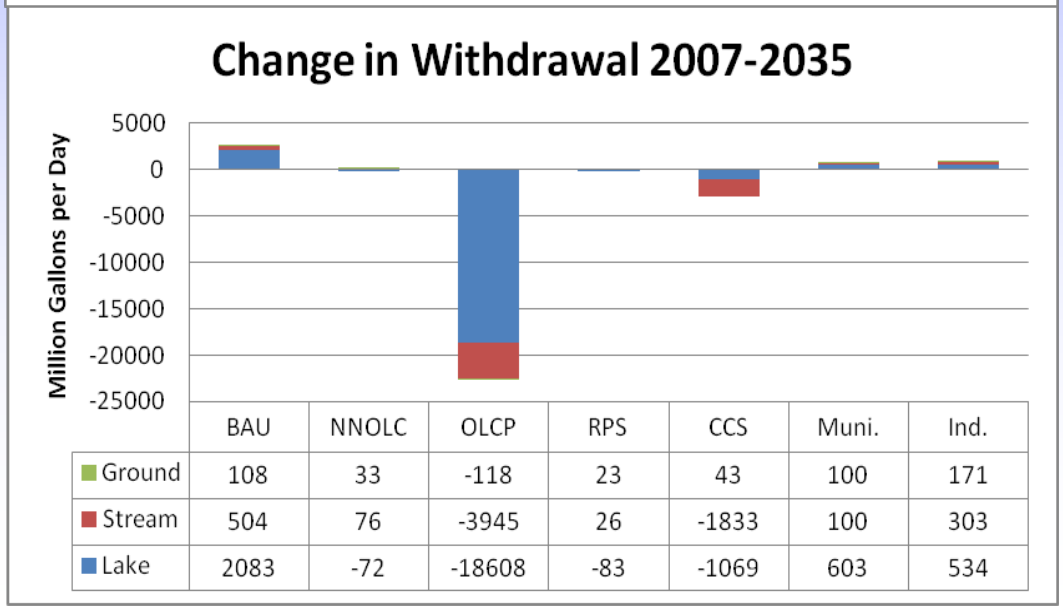
Scenarios: Thermoelectric Withdrawal



	Initial	BAU	NNOLC	OLCP	RPS	CCS	Muni.	Ind.
Ground	755	863	788	637	778	798	580	732
Stream	4450	4954	4526	505	4476	2617	577	1323
Lake	20786	22869	20714	2178	20703	19717	3514	2297



	BAU	NNOLC	OLCP	RPS	CCS	Muni.	Ind.
Ground	108	33	-118	23	43	100	171
Stream	504	76	-3945	26	-1833	100	303
Lake	2083	-72	-18608	-83	-1069	603	534

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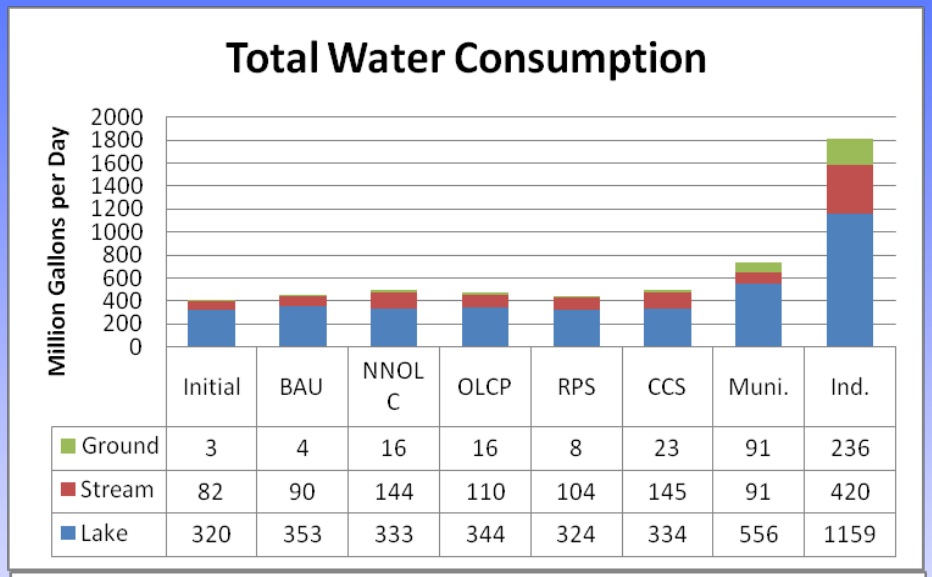
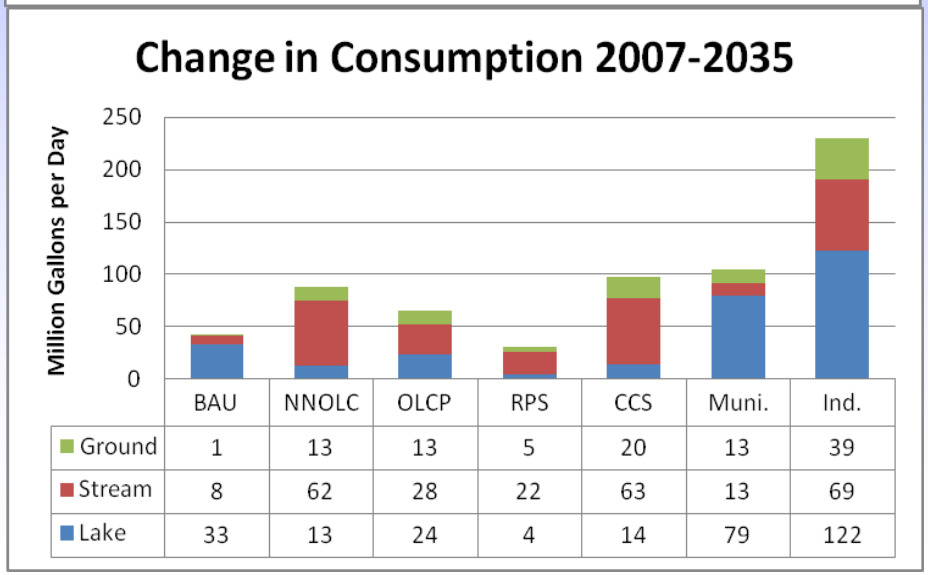
Scenarios: Thermoelectric Consumption



	Initial	BAU	NNOLC	OLCP	RPS	CCS	Muni.	Ind.
Ground	3	4	16	16	8	23	91	236
Stream	82	90	144	110	104	145	91	420
Lake	320	353	333	344	324	334	556	1159



	BAU	NNOLC	OLCP	RPS	CCS	Muni.	Ind.
Ground	1	13	13	5	20	13	39
Stream	8	62	28	22	63	13	69
Lake	33	13	24	4	14	79	122

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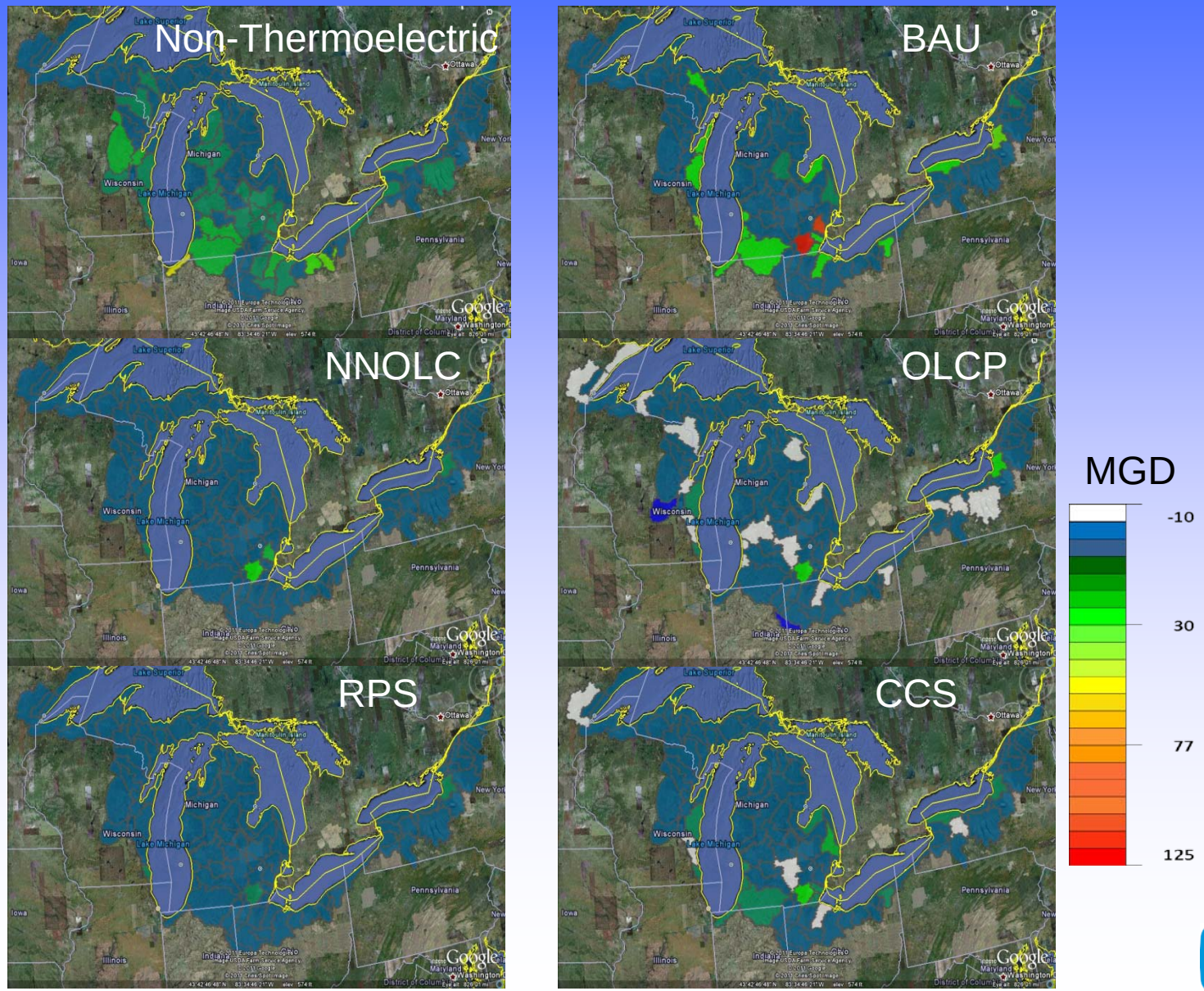
Scenarios: Change in Withdrawals Between 2007-2035



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Key Findings

- Thermoelectric water use characteristics could radically change over the next 25 years due to increasing demands, and potential policies aimed at encouraging green energy development, reducing green-house gas emissions, and regulating large water intake structures.
- According to these five scenarios, water withdrawals for thermoelectric power production in 2035 could grow by 2695 MGD (10%) for the BAU scenario or decrease by 22,671 MGD (87%) for the OLCP scenario. Alternatively, all cases result in growth in consumptive use ranging from 31 MGD (7.6%) for RPS to 97 MGD (24%) for the CCS scenario.
- In comparison non-thermoelectric withdrawals are projected to increase by 1811 MGD while consumption will grow by 335 MGD. Fortunately, some of the new growth in the thermoelectric sector is projected to occur in watersheds experiencing negligible non-thermoelectric growth.

Vulnerable Watersheds

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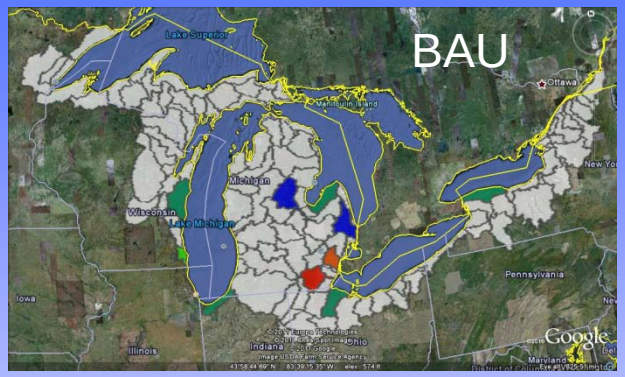
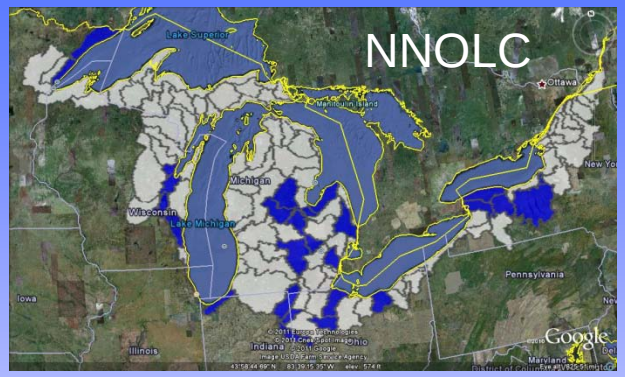
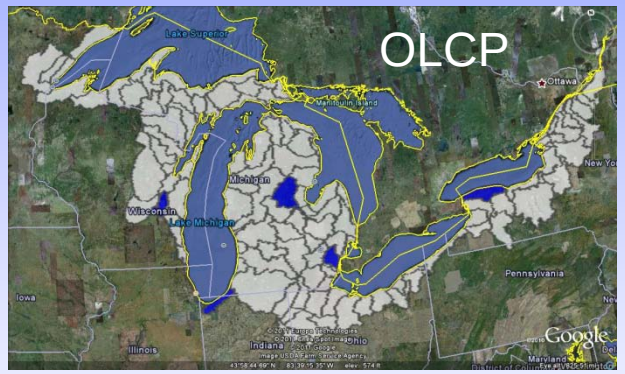
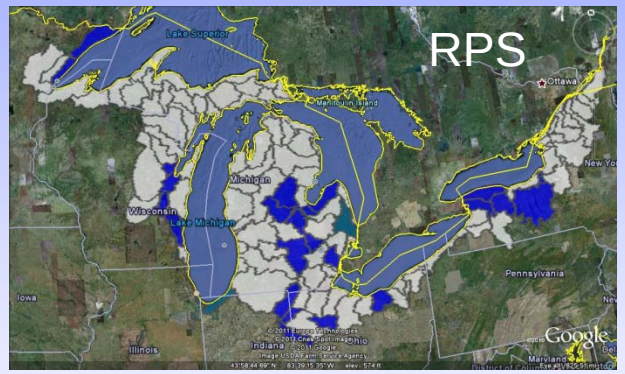
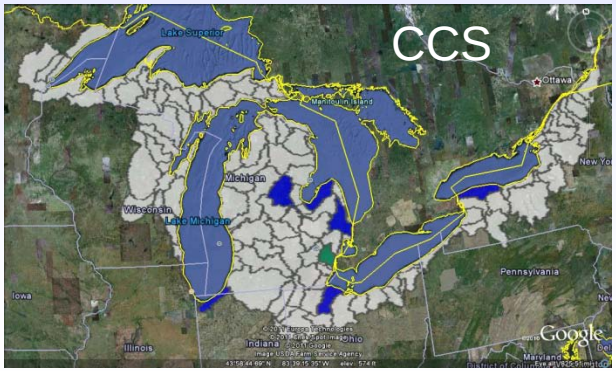
Scenarios: Change in Withdrawal from Vulnerable Watersheds (2007-2035)

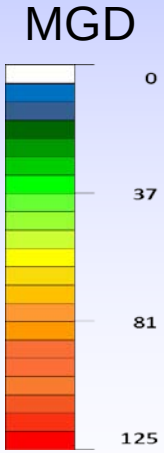












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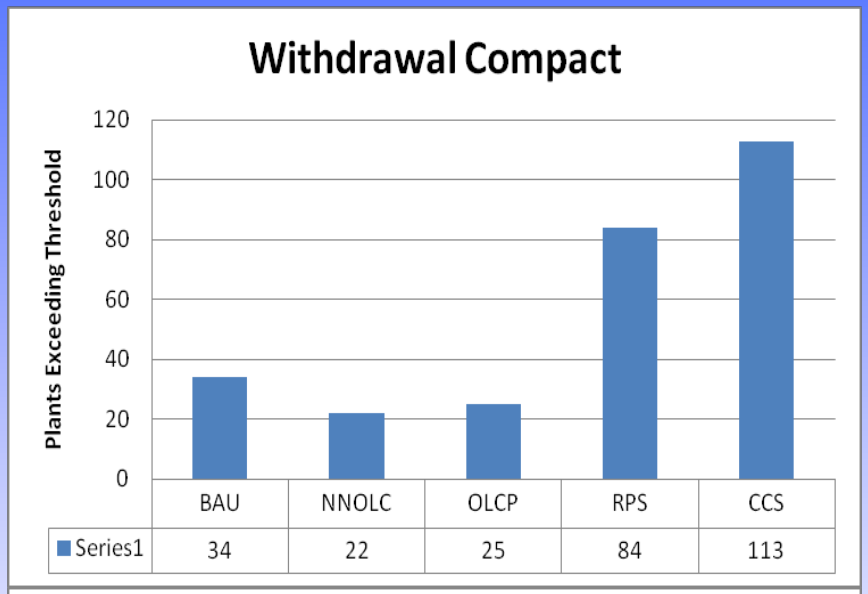
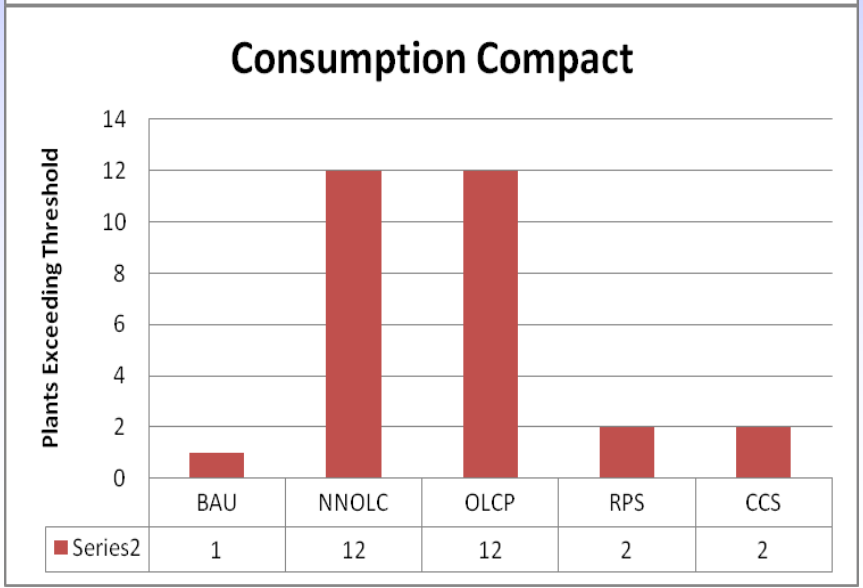
Key Finding

- Any increase in water use has the potential to impact environmental quality of the Great Lakes Watershed. In 2007, twenty-four watersheds or 22% were classified as vulnerable, 19 of which had some thermoelectric withdrawal. Projected growth in the thermoelectric sector is expected to increase the number of watersheds classified as hydrologically vulnerable by 3, 3, and 6 for the NNOLC, RPS and BAU cases respectively. There is no change in vulnerable watersheds for the CCS while the OLCP decreases by 6.

Scenarios: Plants Requiring Permitting Under Compact





Required Permitting 2007-2035

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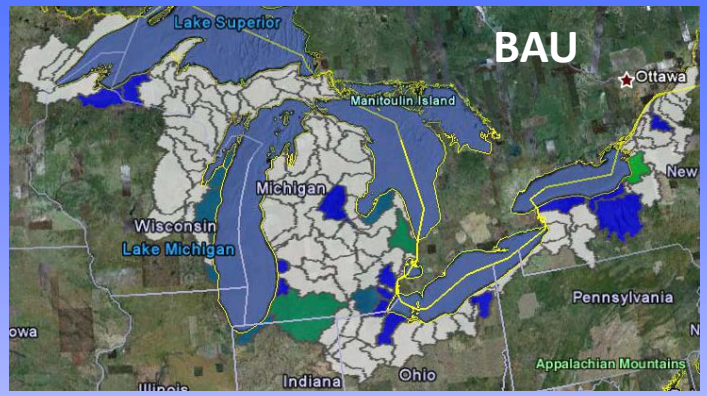
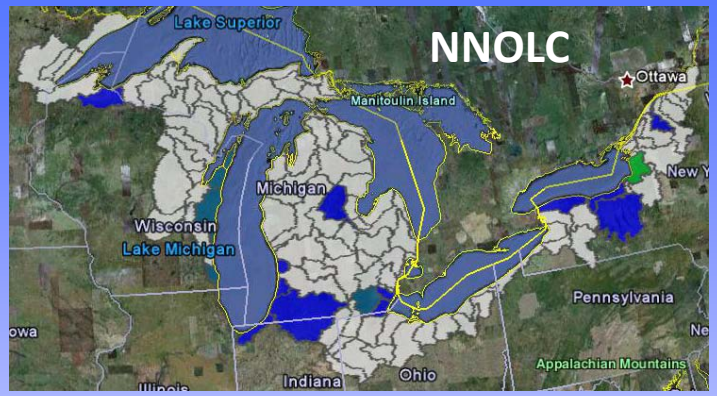
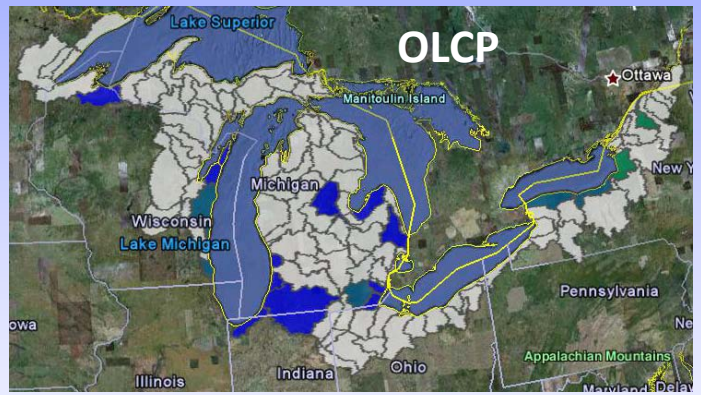
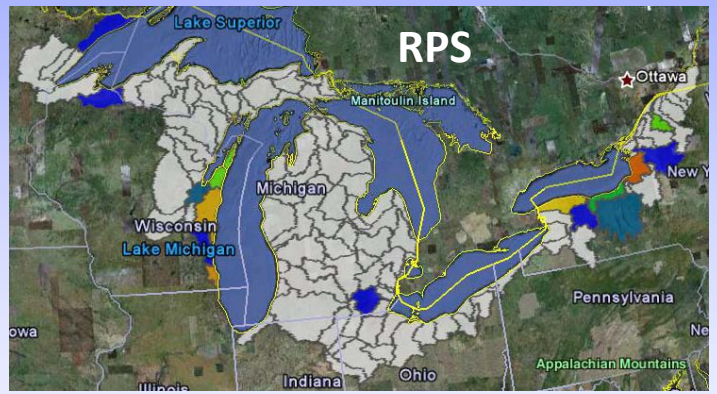
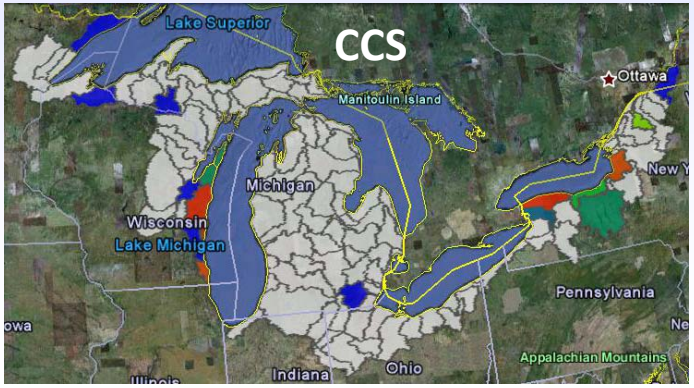
Scenarios: New Plants Exceeding Compact Withdrawal Thresholds

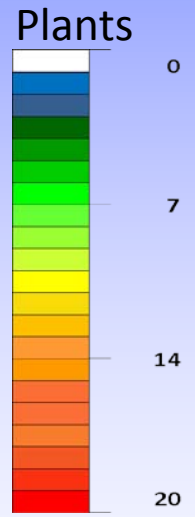












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Key Finding

- Also explored was the potential for new power plants to obtain water withdrawal permits pursuant to state programs required by the Great Lakes and St. Lawrence River Basin Water Resources Compact (state mandated thresholds were used). Permitted facilities would range from 22 (NOLC) to 113 (CCS) and tend to be clustered in New York, Wisconsin, and Michigan. Fewer facilities subject to permitting due to consumptive water use are projected ranging from 1 (BAU) to 12 (316b), which largely match the locations for withdrawal violations.

US Energy Sustainability

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