The Effect of Shale Gas on Power Generation in the Northeast

by

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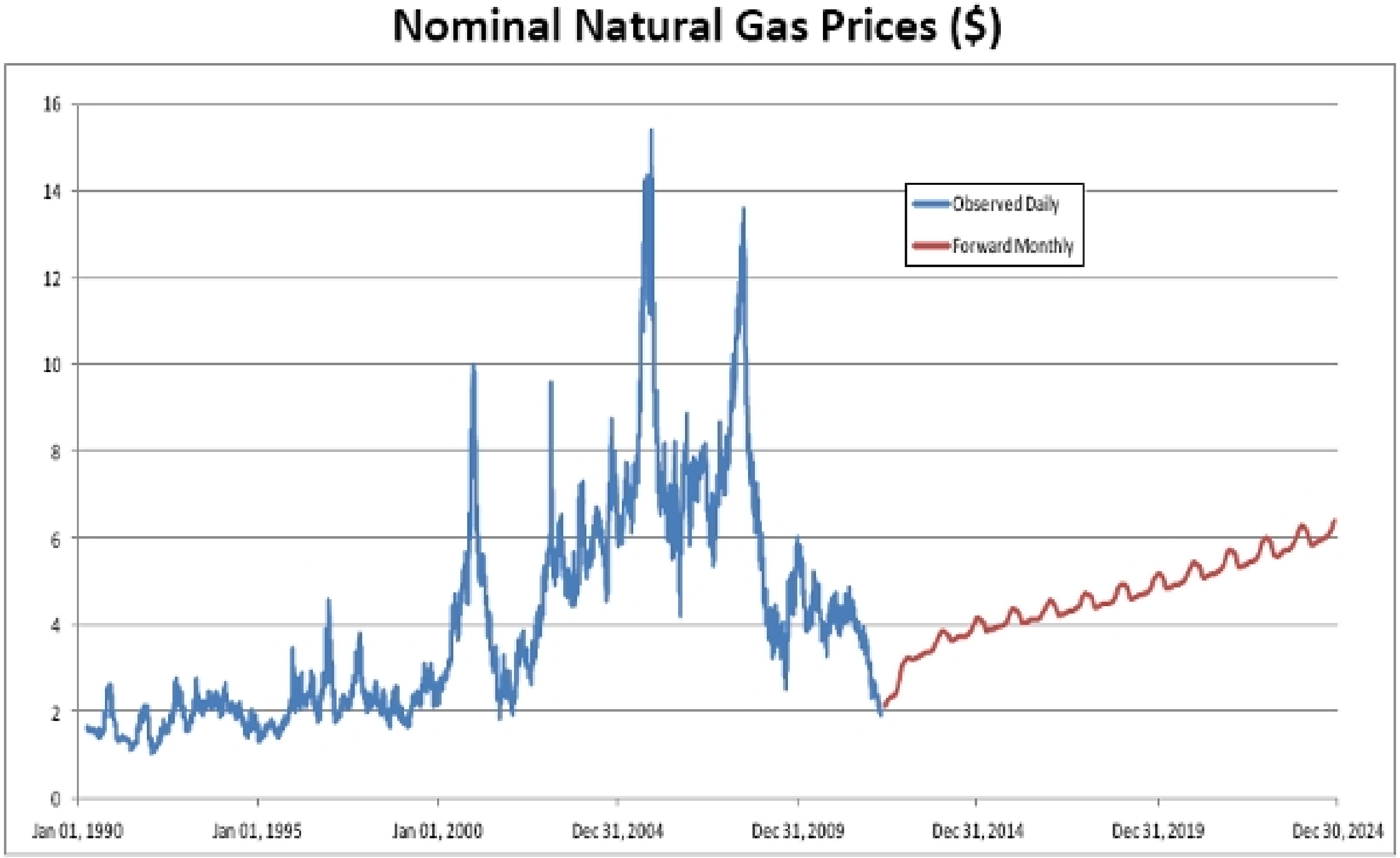
Background

- In the late 1990's, a large number of gas turbine combined cycle plants were proposed throughout the country and in New England.
- In the Northeast, the distribution was approximately 32,000 MW:
  - 12,000 MW in ISO-NE
  - 7,000 MW in NY-ISO
  - 13,000 MW in PJM
- Most were built due to the advantageous economics of natural gas and the efficiency of the combined cycle turbines
  - GTCC = $3/MMBtu * 6,700 Btu/kW-hr/10^6 Btu/MMBtu = **$0.021/kW-hr**
  - Coal = $3/MMBtu * 10,000 Btu/kW-hr/10^6 Btu/MMBtu = **$0.03/kW-hr**
- With the low cost of natural gas, GTCCs were projected to produce power much more cheaply than the older inefficient units

Then, This Happened

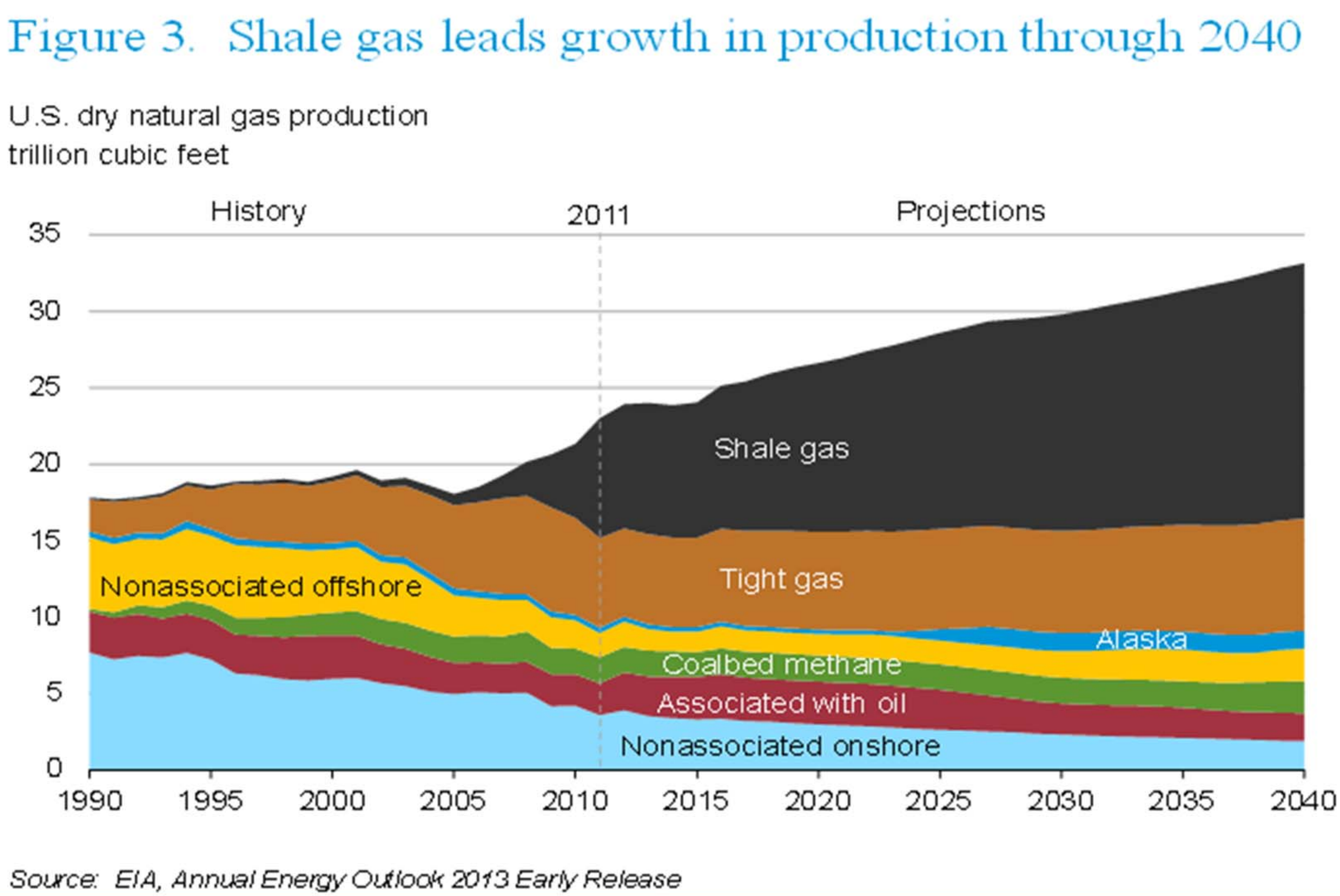


Source: NYMEX

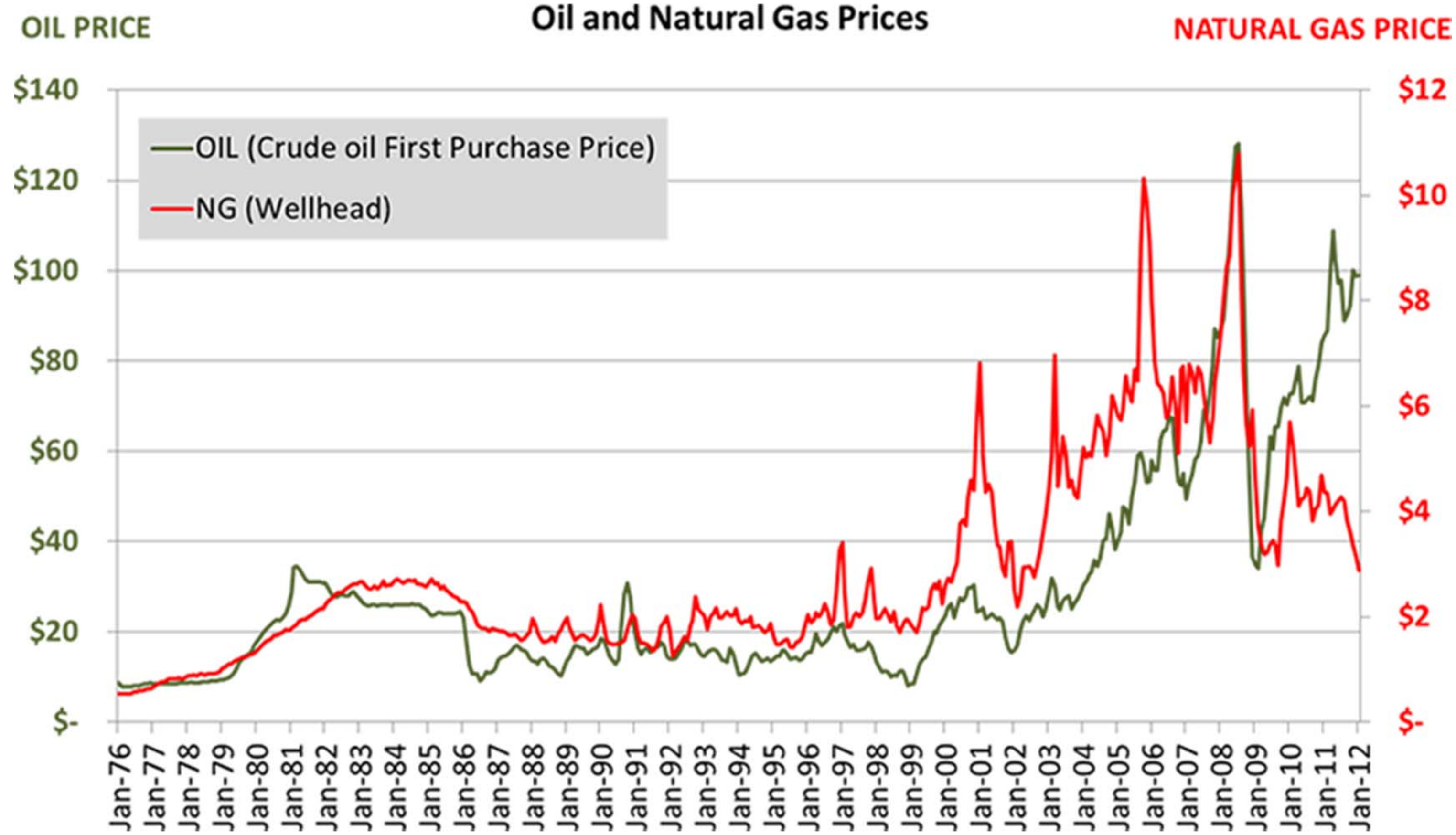
Increased Gas Costs

- The increased natural gas costs eliminated any advantage over conventional facilities
  - The peak generation costs increased from $0.02/kW-hr to more than $0.10/kW-hr
  - Peak gas were in the fall/winter of 2005-6 and the summer of 2008, two peak operating periods
- These plants subsequently operated much less often than anticipated
  - GTCCs became the “marginal” power plants (i.e., the last plants turned on in the queue)
  - Some GTCCs could not afford to operate to perform their annual stack tests
  - Annual average utilizations were in the range of 30-50%, when they were anticipated to be in the range of 90%
  - Capacity factors for GTCCs were in the range of 26-37% so when they were operating, they weren’t operating at 100% load
  - Many of the GTCCs changed hands several times since their economics did not allow them to be profitable

Fortunately, This Happened



Fortunately, This Also Happened



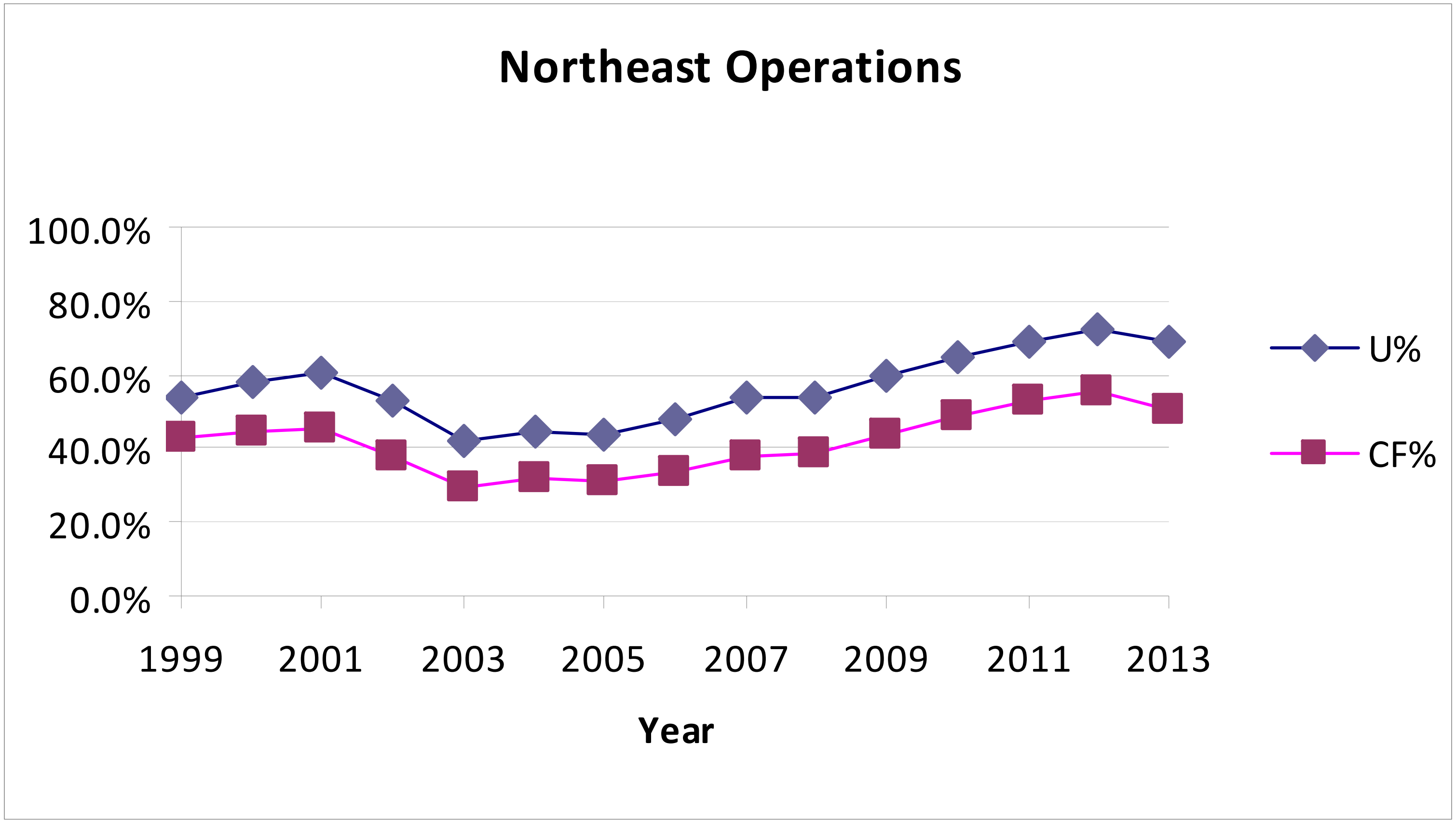
Shale Gas Production Took Off

- Shale Gas production increased from minimal amounts in 2005, when the GTCCs were having the most difficulty
  - Production was <1 TCF
  - By 2011, overall production was approximately 10 TCF
  - The increased gas supply reduced their fuel costs, resulting in increased operations (i.e., no longer the marginal rate)
- Gas Prices Decoupled from Oil
  - Historically, natural gas had nearly always trended more expensive than oil
  - In mid-2009, oil trends more expensive than natural gas
- Will review the operations from 2007 to the present to evaluate the effect of the shale gas
  - Evaluate what happened to the GTCCs
  - Evaluate how operations changed at conventional plants
    - Including case studies at several large coal- and oil-fired plants
  - Evaluate reduction in overall emissions

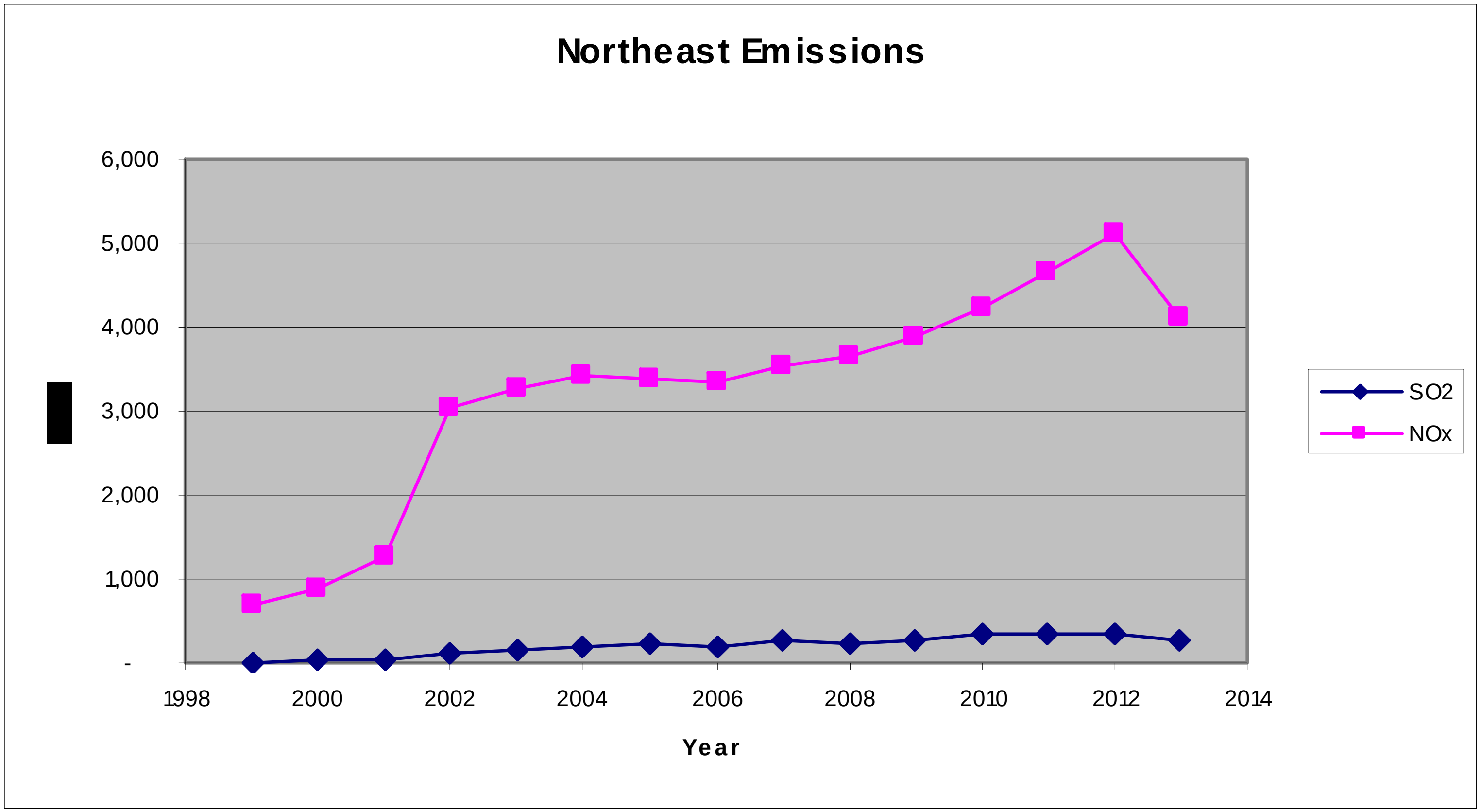
What Happened at the GTCCs

- Reviewed EPA's operational records including:
  - facility operations (hours per time period)
    - Can calculate utilization
  - heat input (MMBtu)
    - Can calculate capacity factor based on unit maximum rate
  - power output (sometimes ignores steam turbine)
  - NOx, SO2 and CO2 emissions
    - Fuels can be inferred from emission rates
    - Short term (tons) and long term rates (lb/MMBtu)

What Happened at the GTCCs



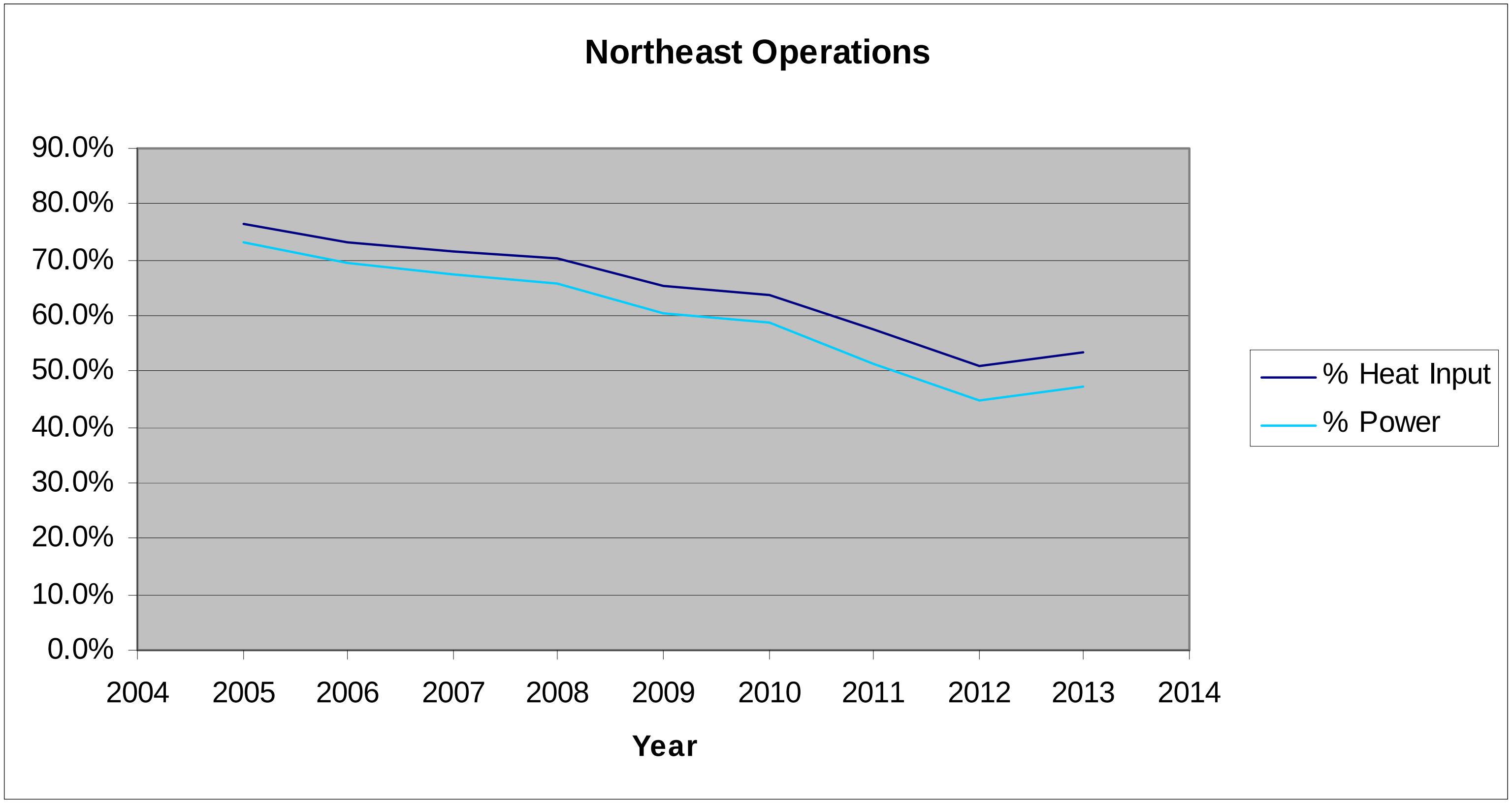
What Happened at the GTCCs



What Happened at Conventional Plants

- Conventional (Steam cycle) plants
  - The best of which had ~10,000 Btu/kW-hr heat rates
  - Most often, coal or oil fired
  - Facilities that have added natural gas firing, were more inefficient and had been derated
  - State of the art technology for the 1960s

What Happened at Conventional Plants



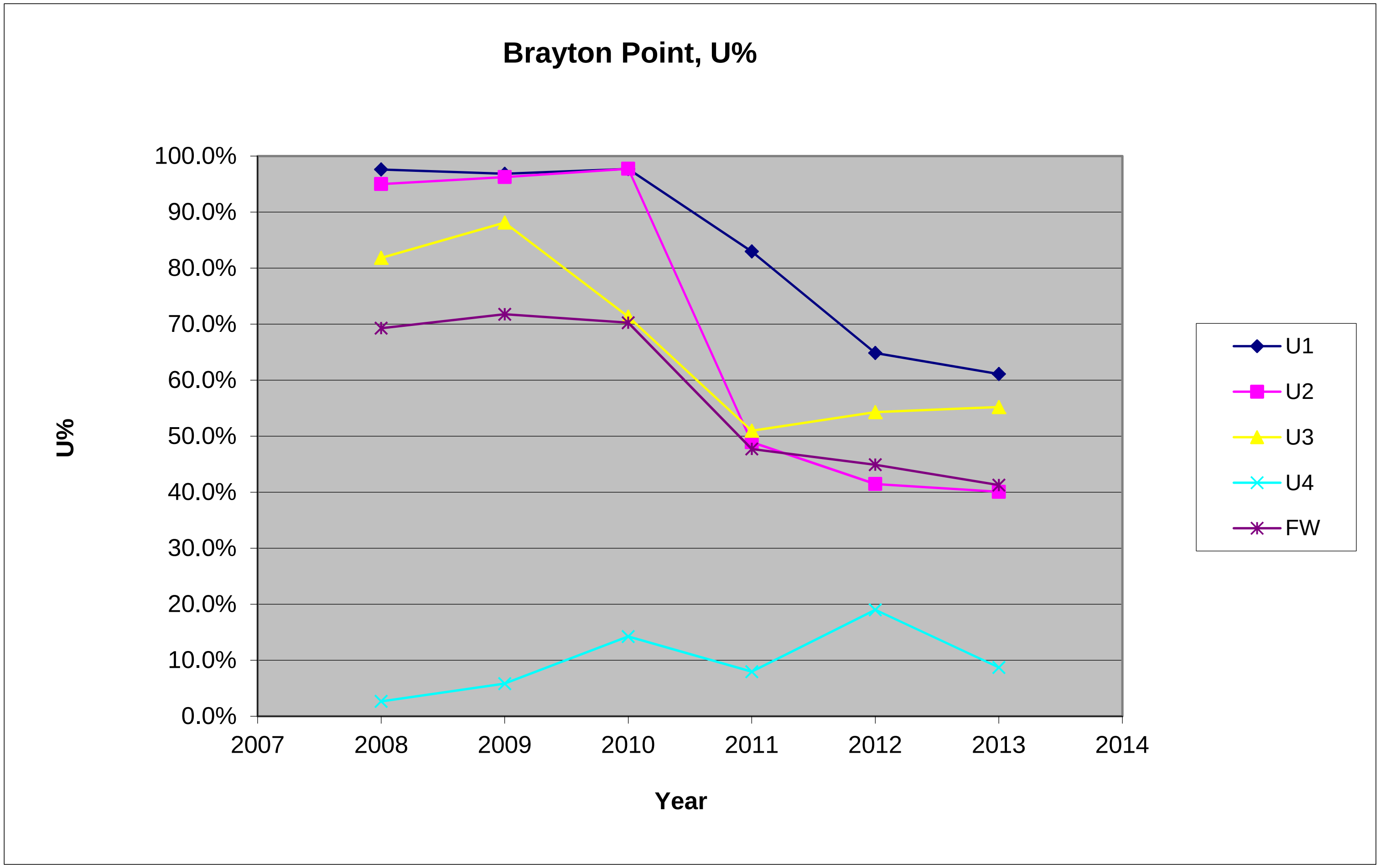
What Happened at Conventional Plants

- In addition to the increased gas supply, the conventional plants were facing:
  - New air emission regulations
    - CT, MA and NJ have fuel sulfur requirements
    - NJ and NY have NOx RACT Part 2, PA working on it
    - Massachusetts' 310 CMR 7.29
      - Brayton Point invested $530 million in pollution controls
    - Connecticut's Requirements for Existing Plants
    - CAIR (SO2 and NOx) – FGD/DSI/SCR/lower S fuels
    - NESHAP/Boiler MACT (Hg, acid gases)
    - Greenhouse Gas
  - Purchase of RGGI Allowances (all but PA and NJ)
  - 316(b) requirements for cooling systems
    - Brayton Point invested $570 million in new cooling towers
  - Sierra Club NAAQS Modeling

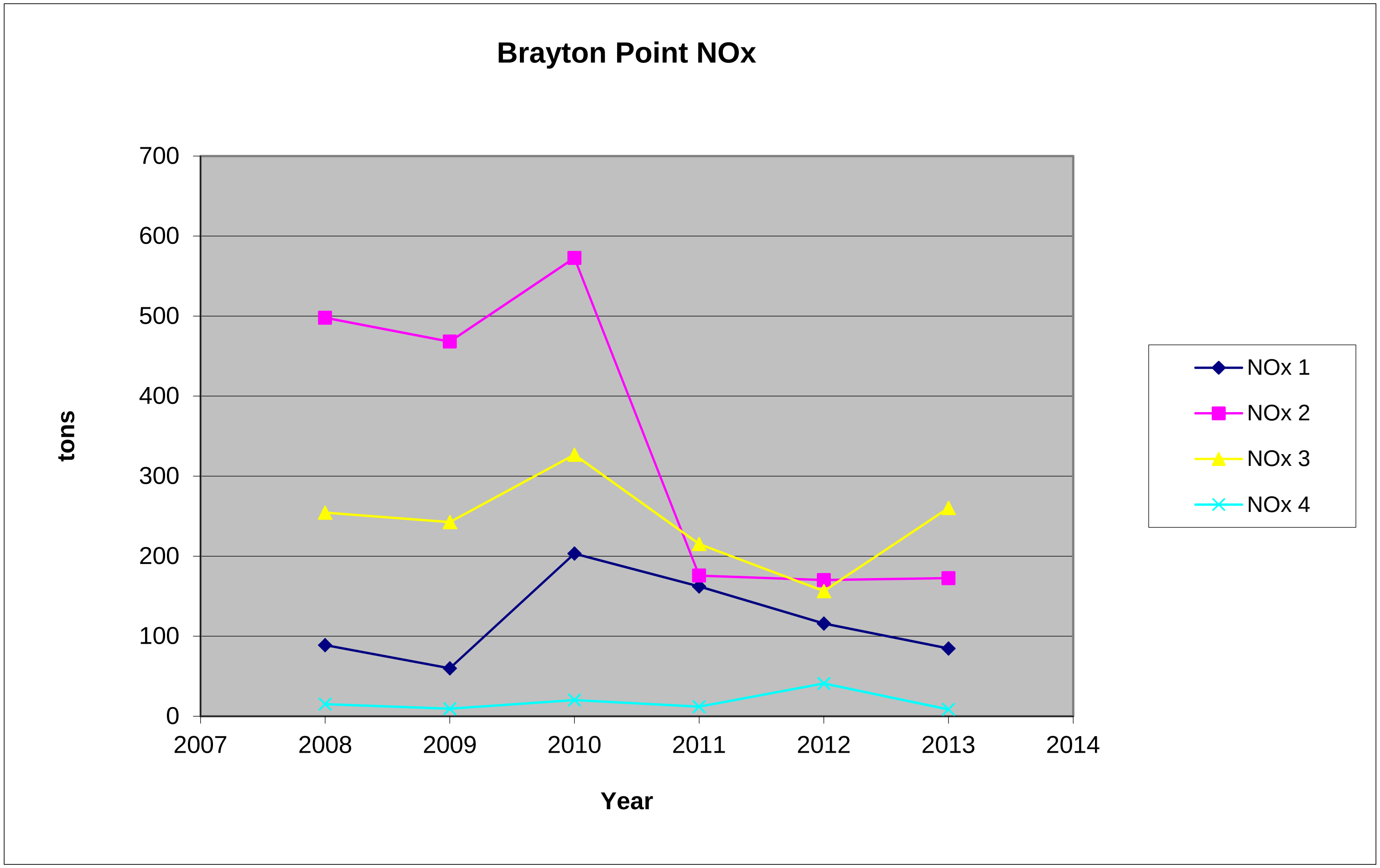
Case Studies at Conventional Plants

- **Several Plants Examined:**
  - Brayton Point, MA
    - Fuels: Coal, Oil and Gas, 1,600 MW, Built in 1963-1974, to be closed in 2017
  - Canal, MA
    - Oil and Gas, 1,165 MW, Built in 1968-1976, still operating
  - Salem Harbor, MA
    - Coal, Oil and Gas, 745 MW, Built in 1951-1972, to be replaced with GTCC
  - Danskammer, NY
    - Coal, Gas and Oil, ~500 MW, Built in 1951-1967, TBD
  - B L England, NJ
    - Coal and Oil, 400 MW, Built in 1962-1974, still operating
  - R. Paul Smith Power Station, MD
    - Coal, 90 MW, Built in 1947-1951, closed in 2012

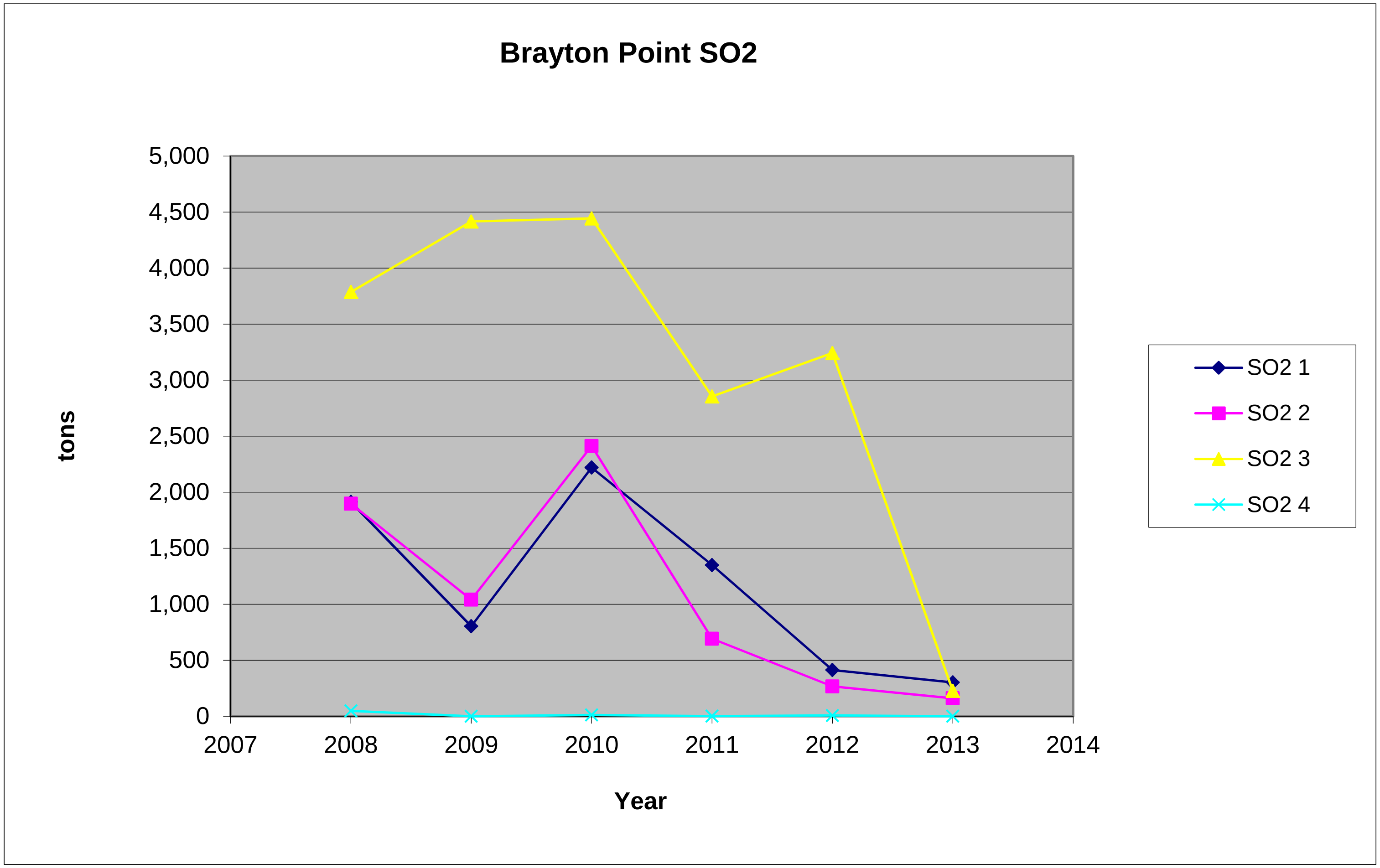
Brayton Point, Summer Operations



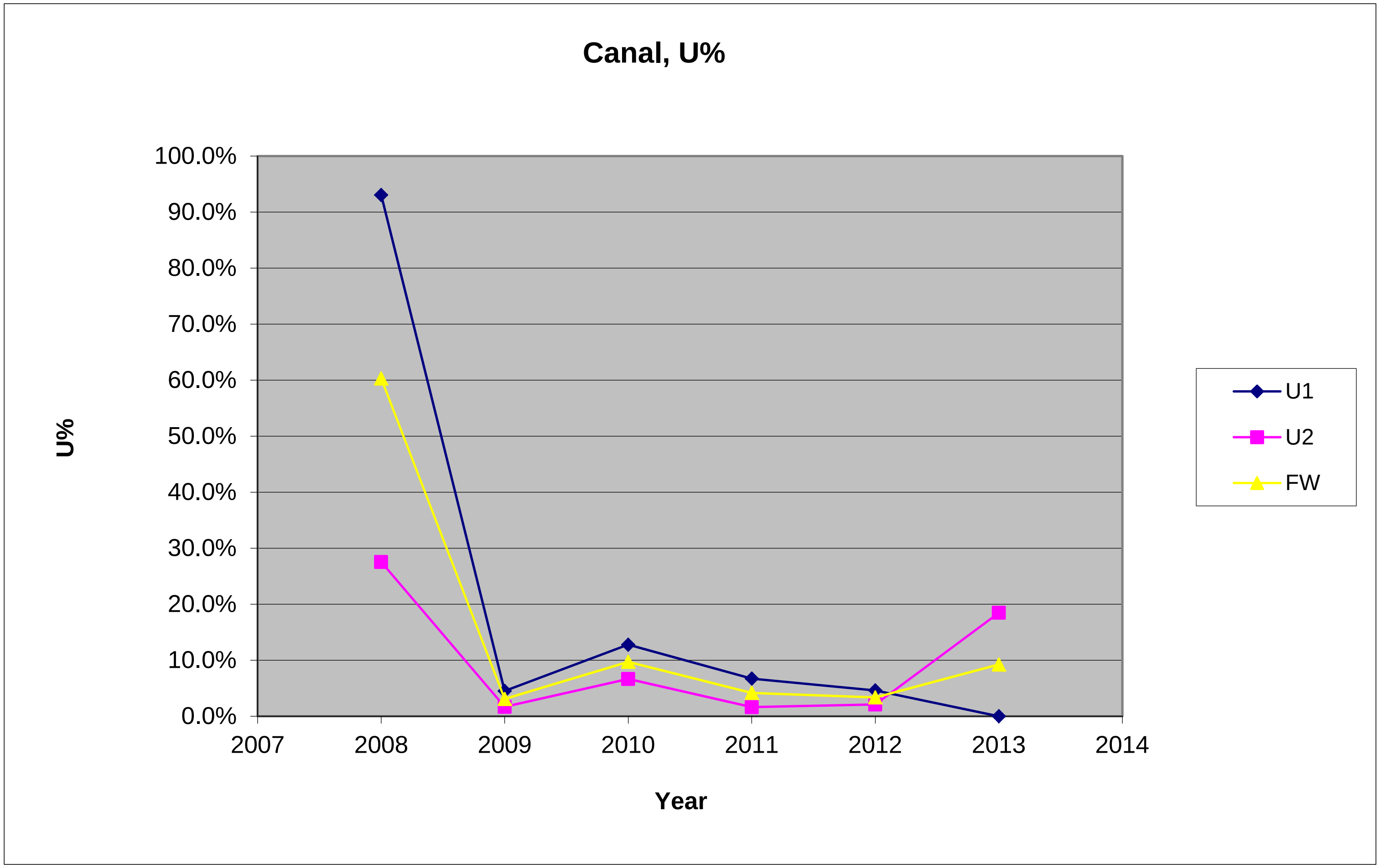
Brayton Point, Summer NOx Emissions



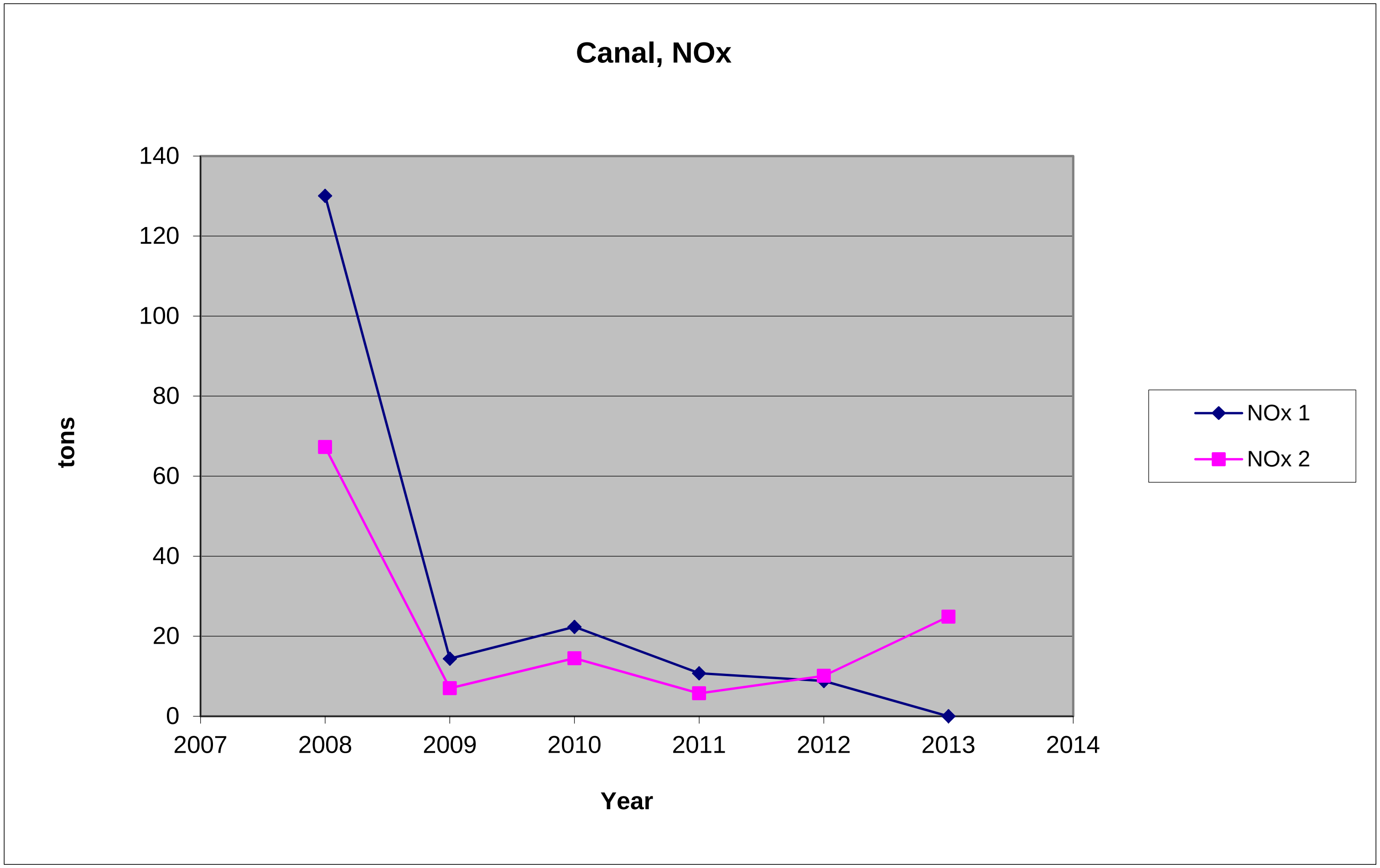
Brayton Point, Summer SO2 Emissions



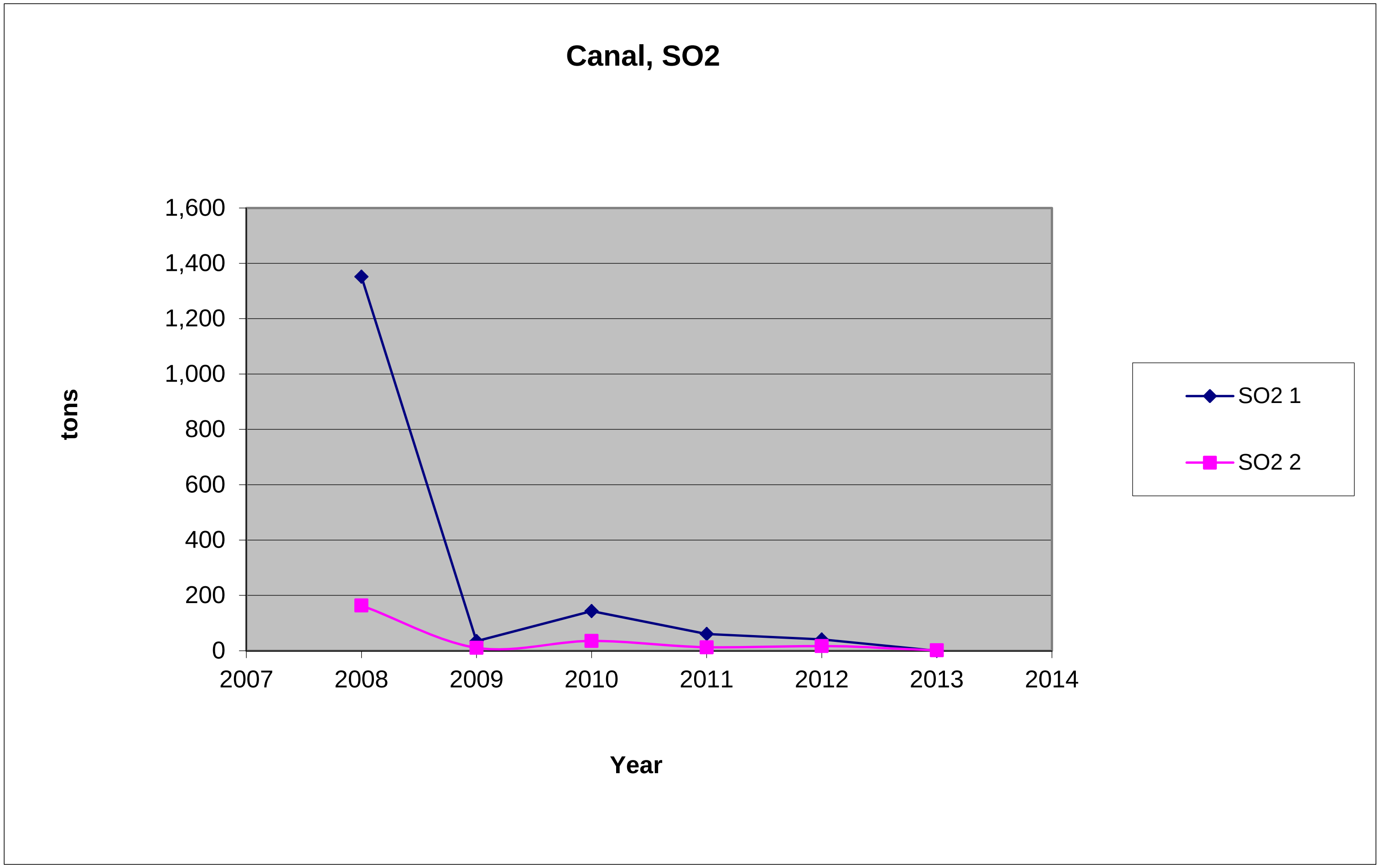
Canal, Summer Operations



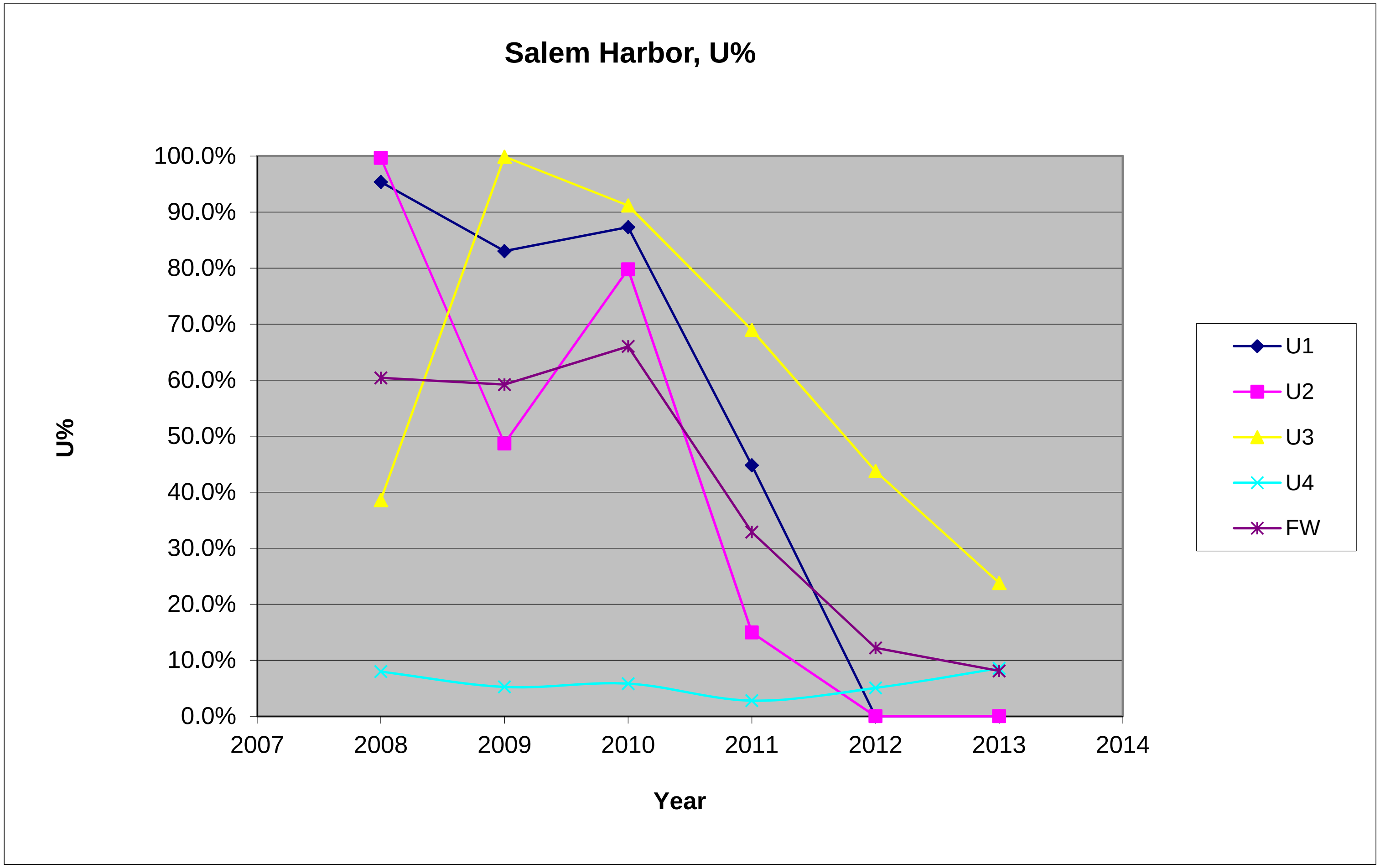
Canal, Summer NOx Emissions



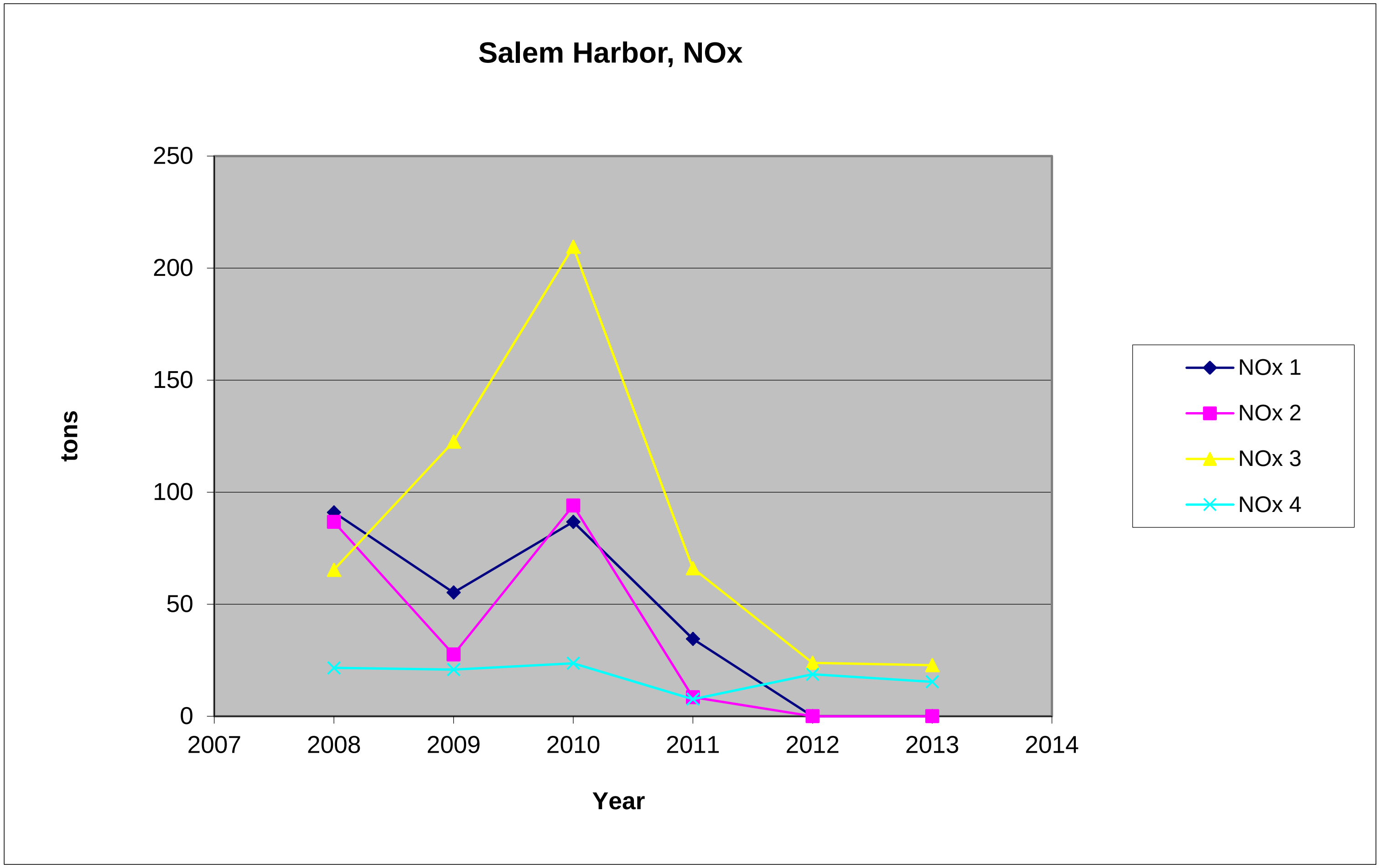
Canal, Summer SO2 Emissions



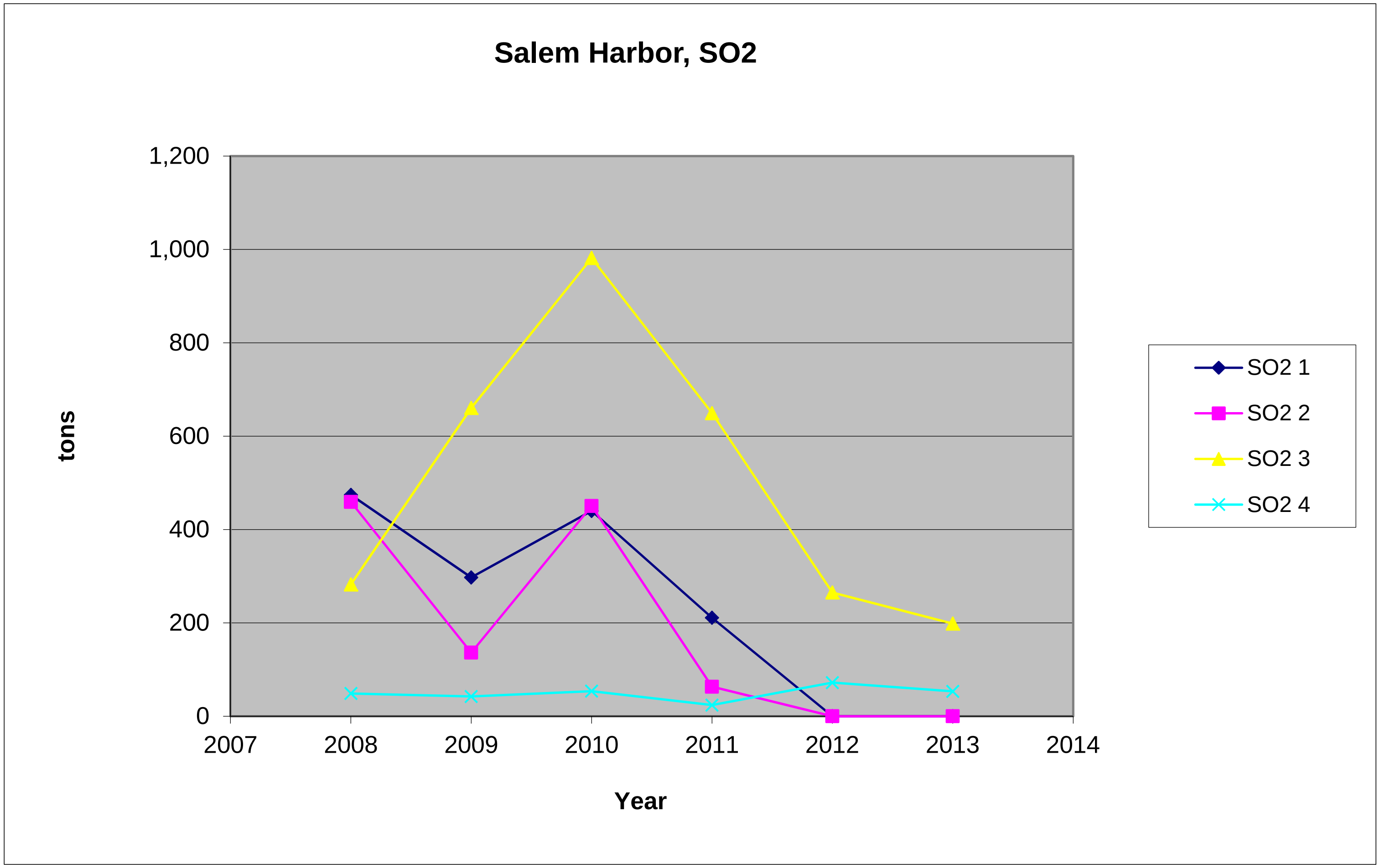
Salem Harbor, Summer Operations



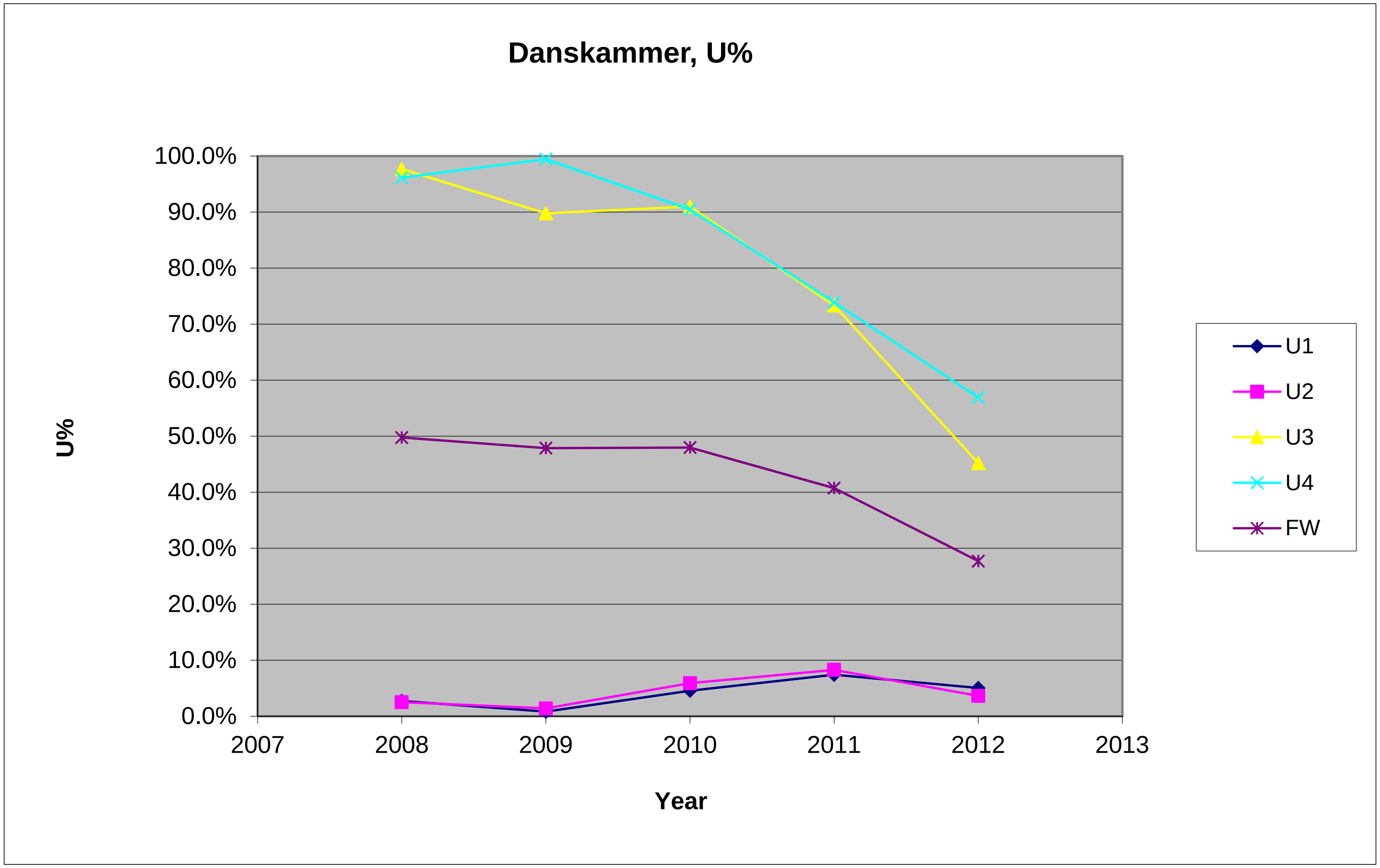
Salem Harbor, Summer NOx Emissions



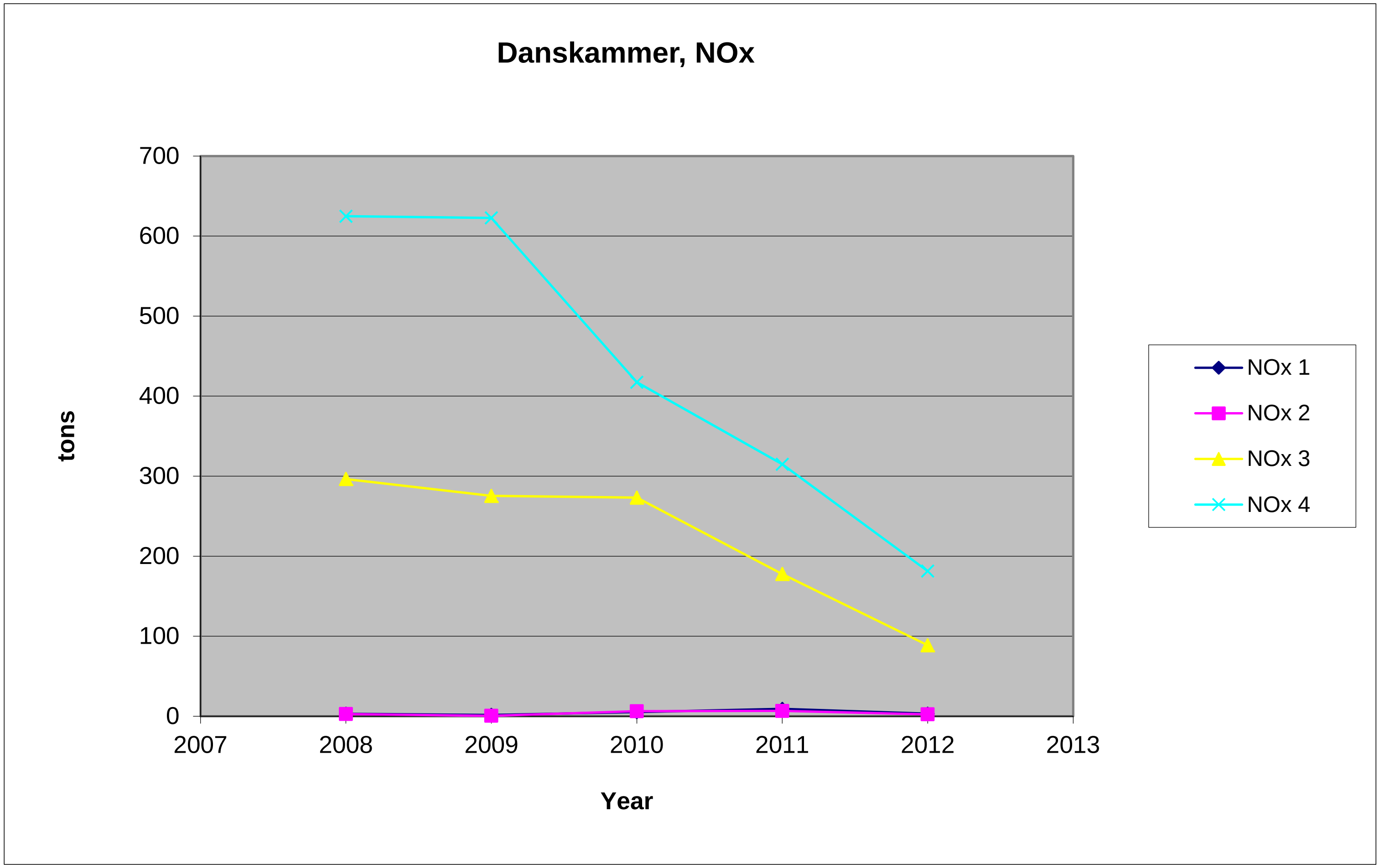
Salem Harbor, Summer SO2 Emissions



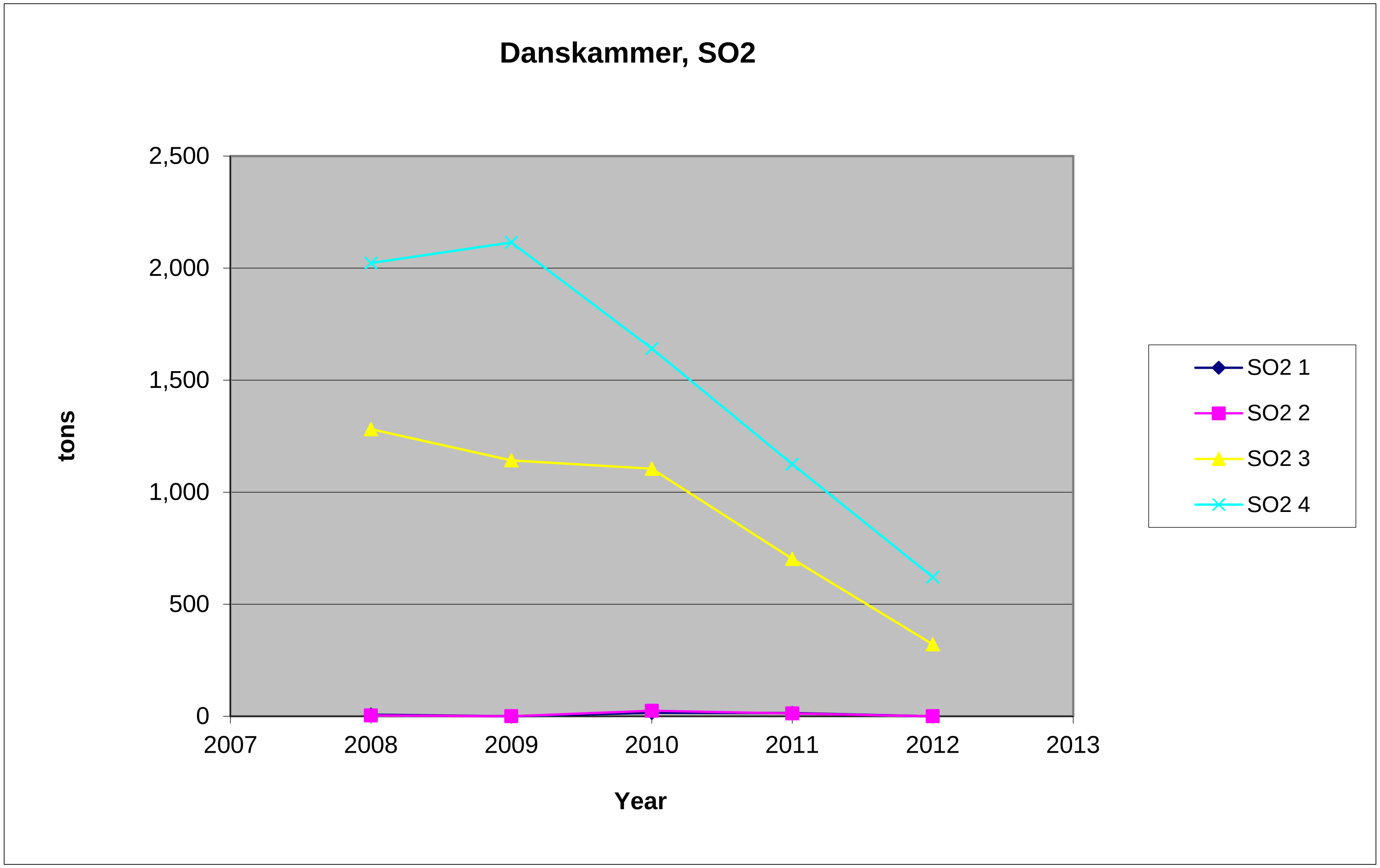
Danskammer, Summer Operations



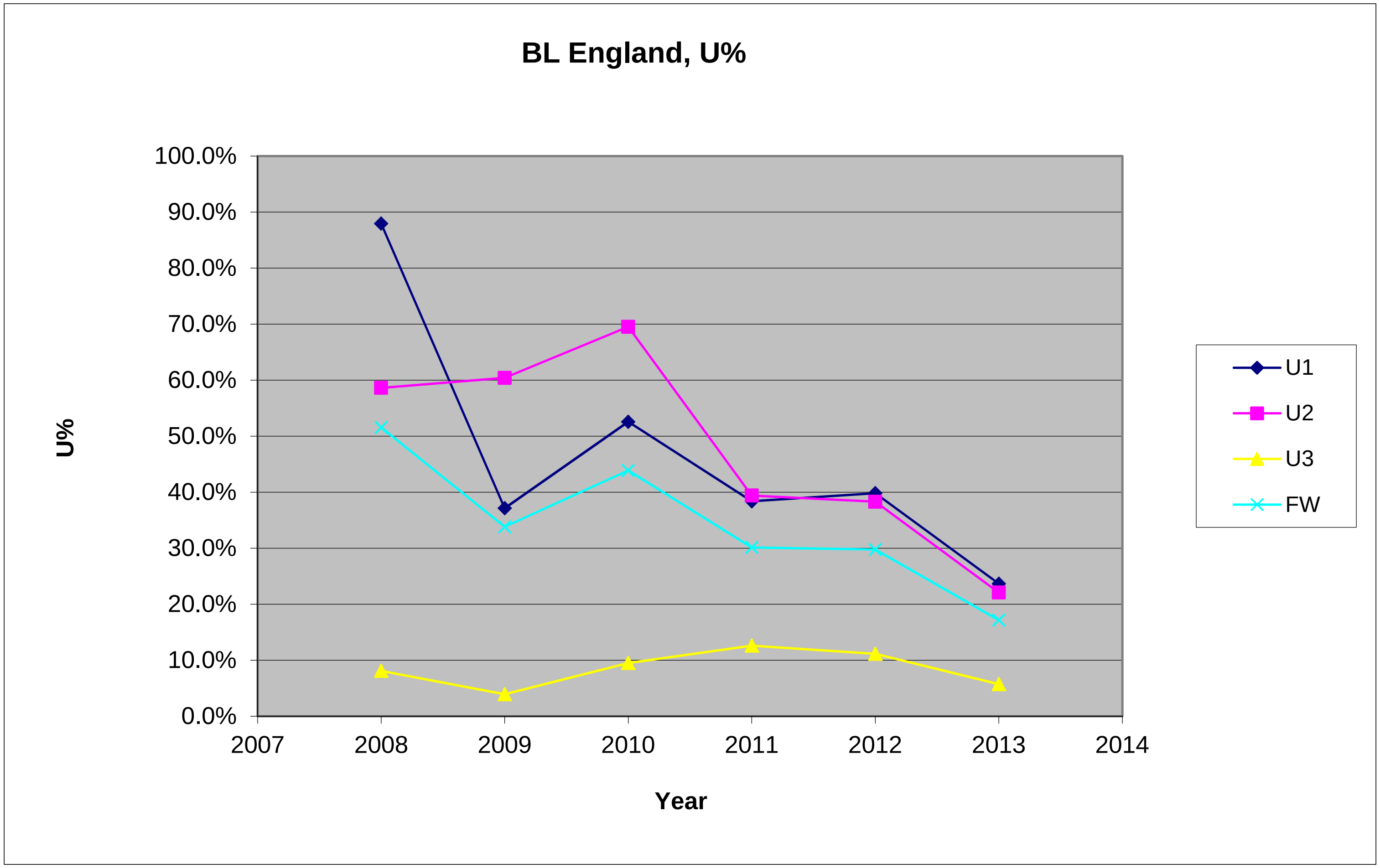
Danskammer, Summer NOx (tons)



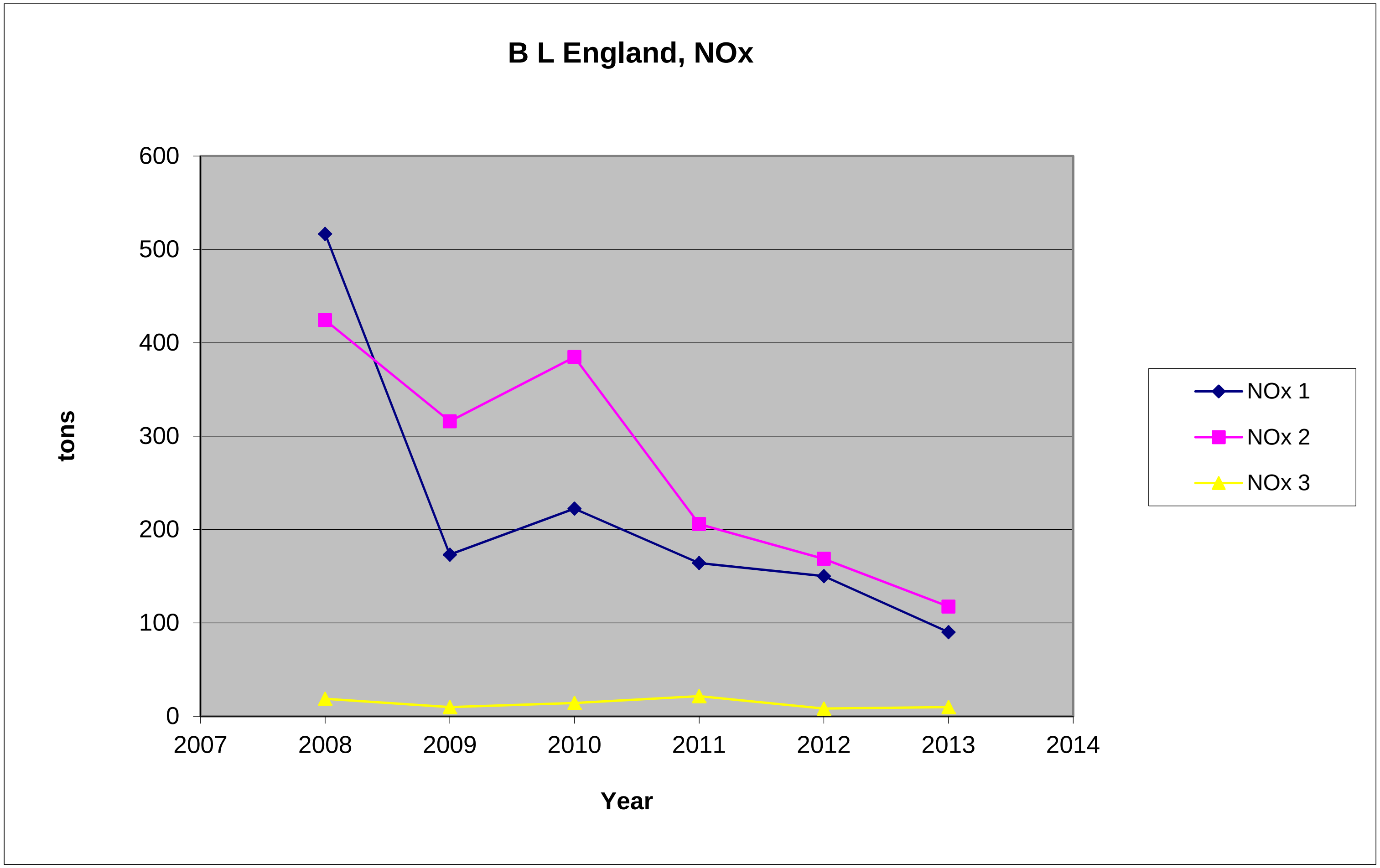
Danskammer, Summer SO2 (tons)



B L England, Summer Operations



B L England, Summer NOx (tons)



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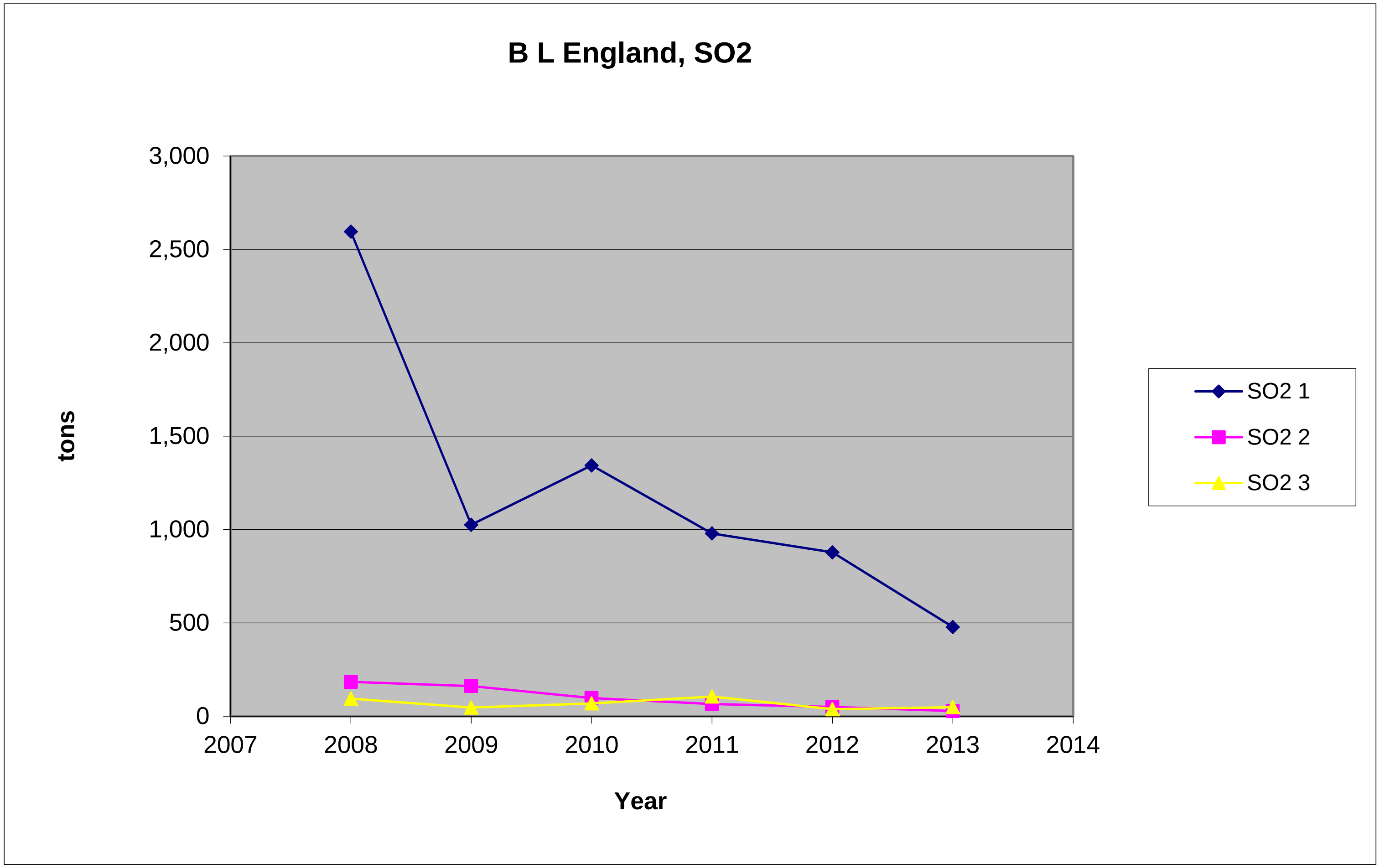
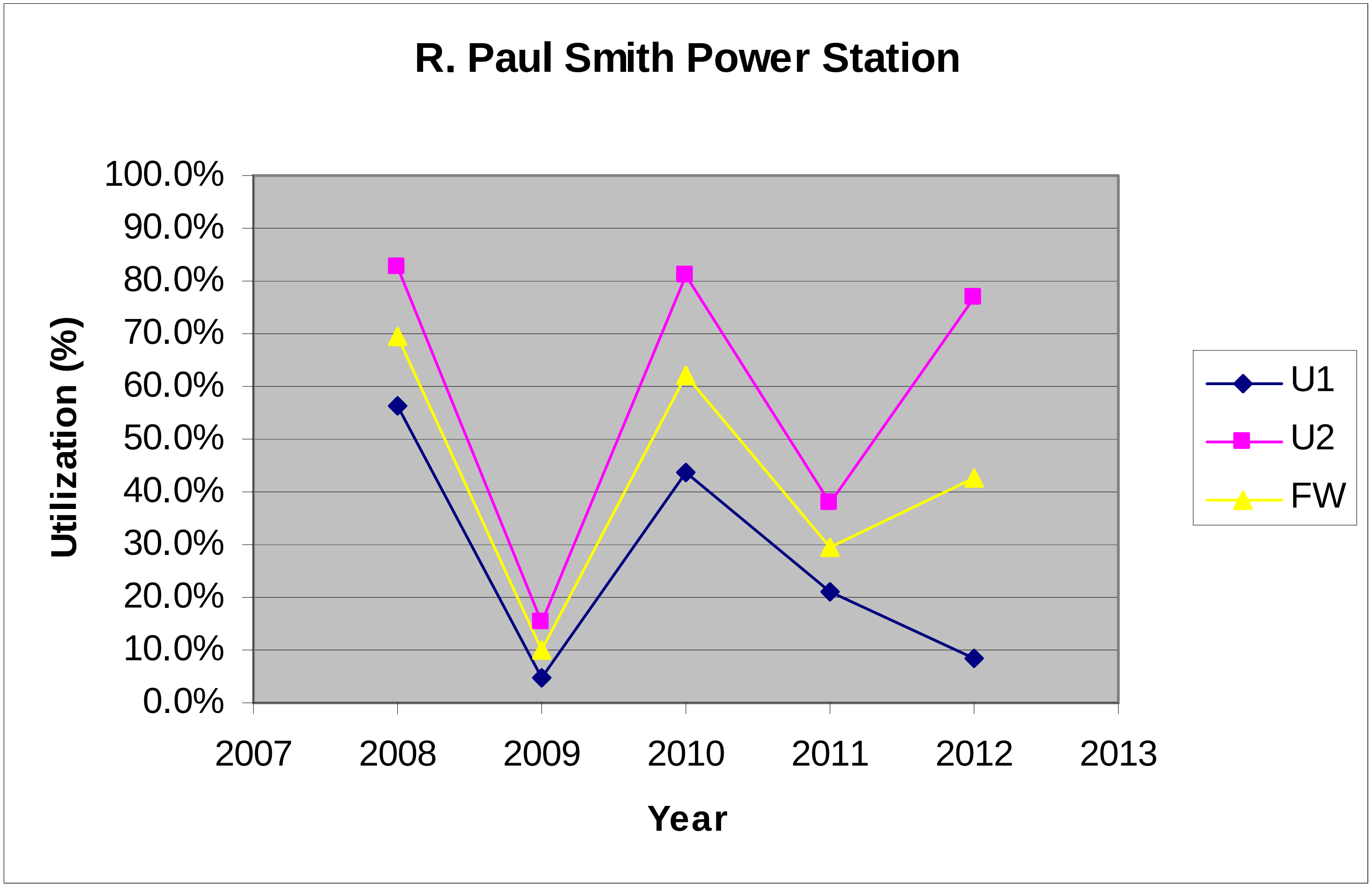
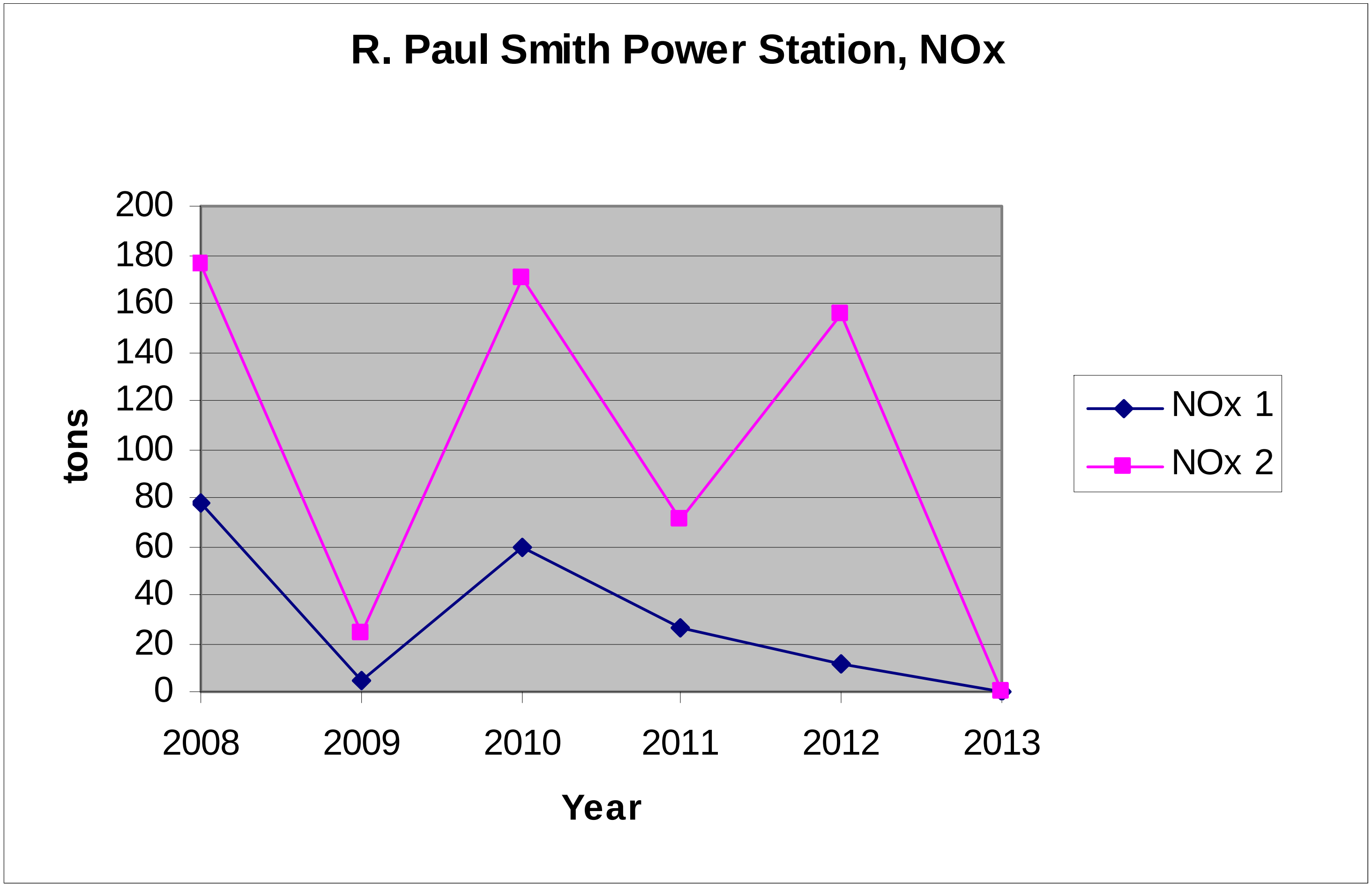


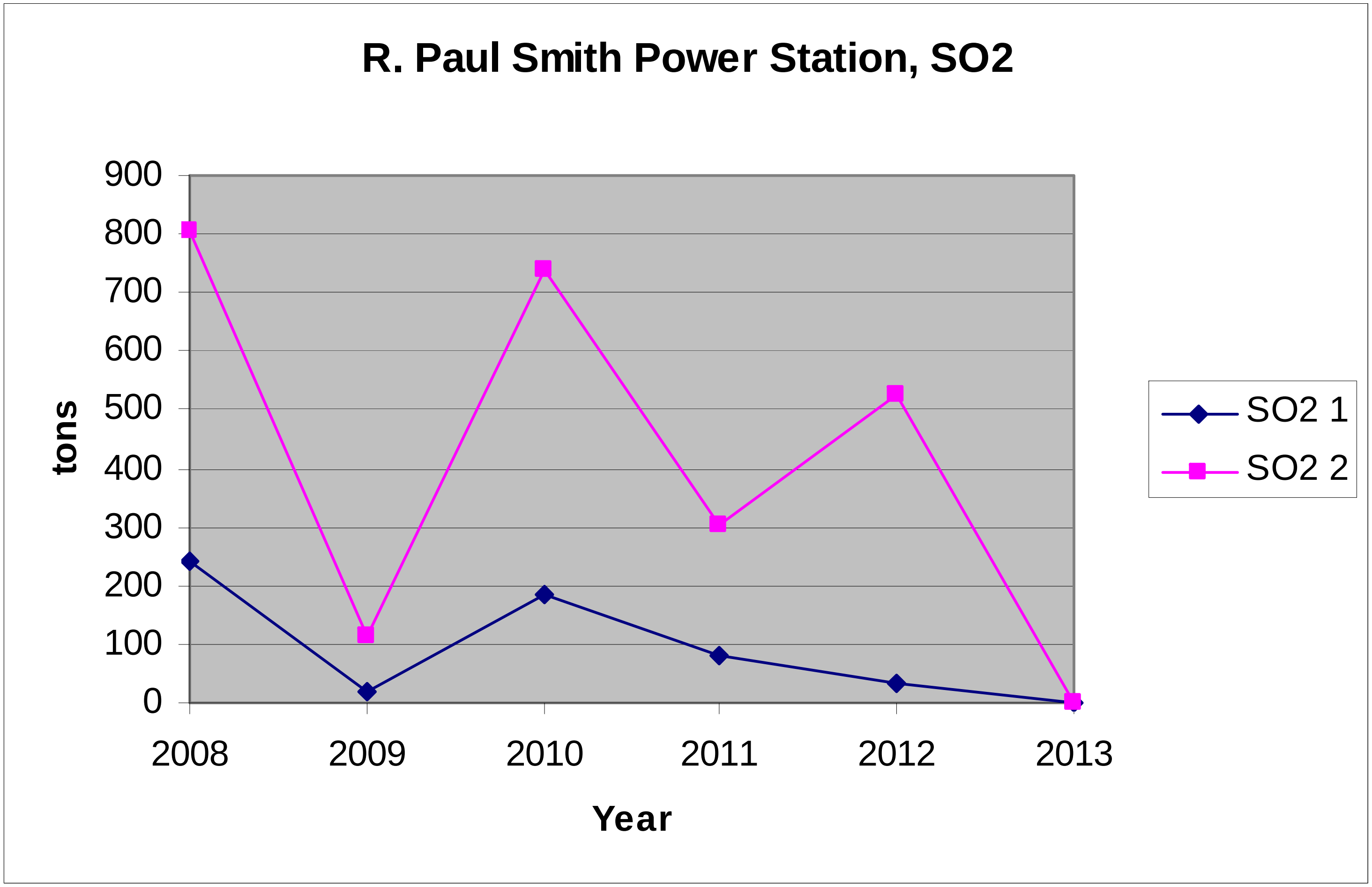
R. Paul Smith Power, Summer Operations



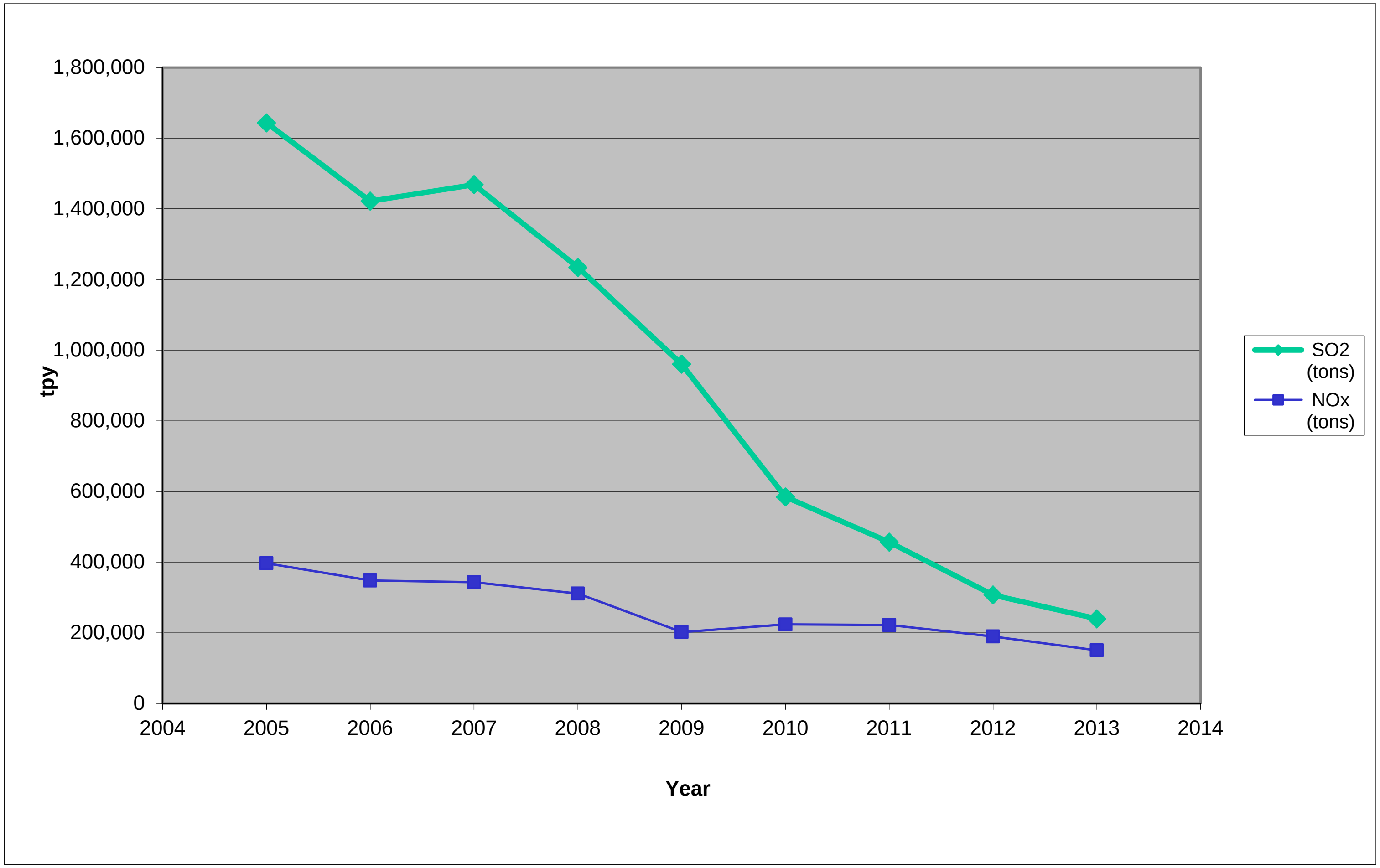
R. Paul Smith Power, Summer NOx



R. Paul Smith Power, Summer SO2



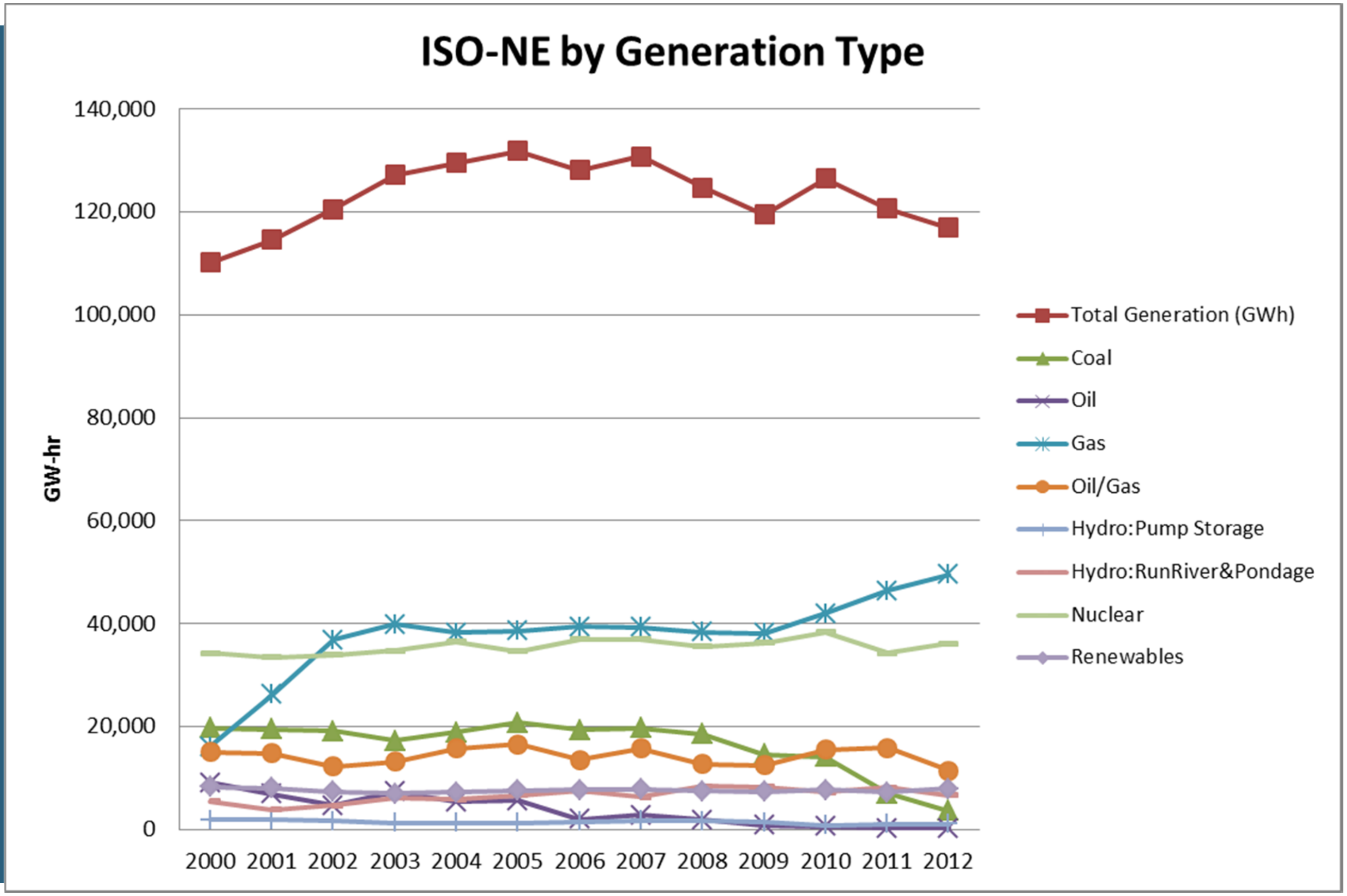
Overall Emissions Reductions in the Northeast (ISO-NE, NYISO and PJM)



What Happened Overall in the Northeast

- Overall, the reductions in the Northeast were substantial:
  - From 2008 to 2012, the total reductions were:
    - 75% SO_2 (927,000 tpy)
    - 39% NO_x (121,000 tpy)
    - 12% CO_2 (30 million tpy)
    - 10% heat input (329 million MMBtu)
    - 4% power output (12,200 GW-hr)
- Generated substantial investments
  - Many new GTCCs were licensed and constructed
  - GTCCs were sold repeatedly over the last 10 years
  - Large Investment in keeping conventional units in pollution control technology
  - Now, these same conventional units are beginning to be retired

What Happened Overall in the Northeast



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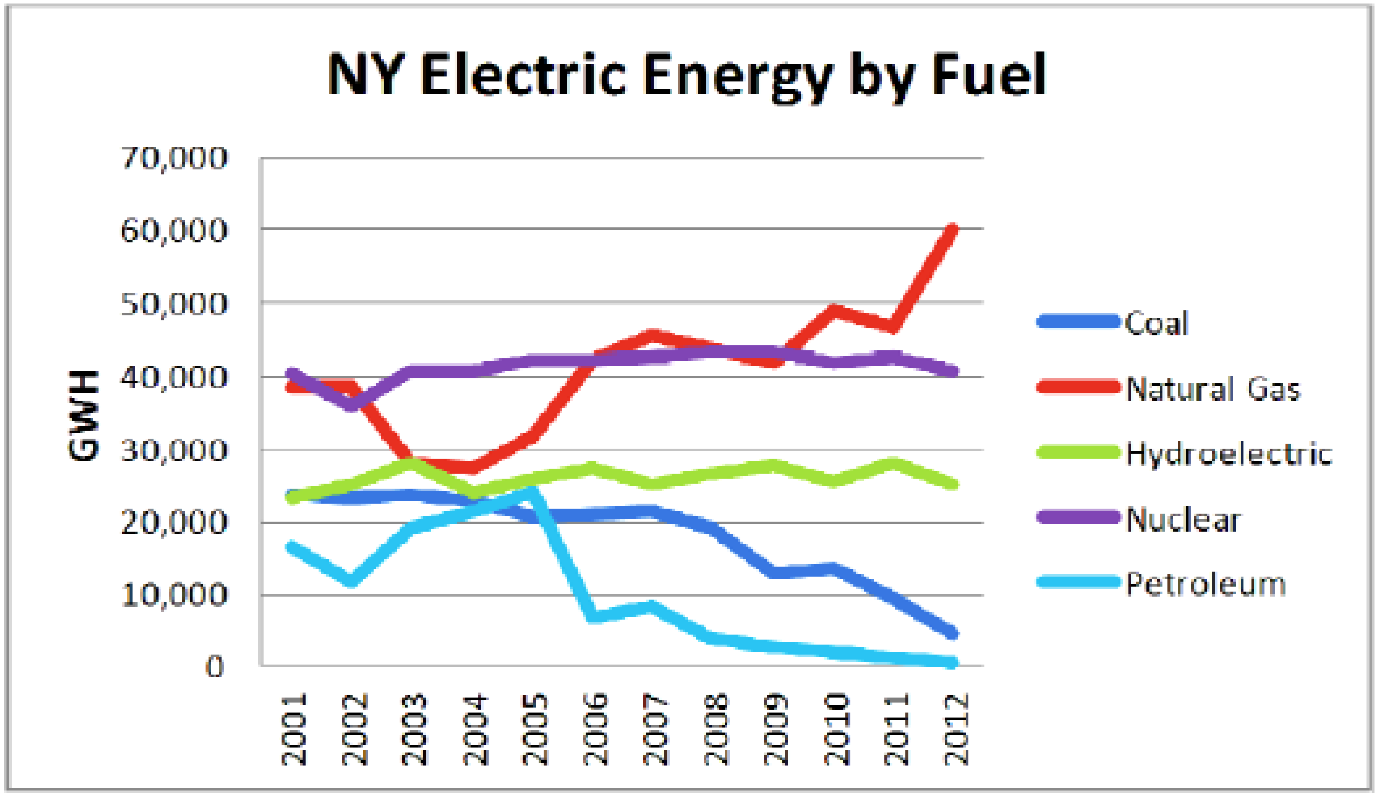
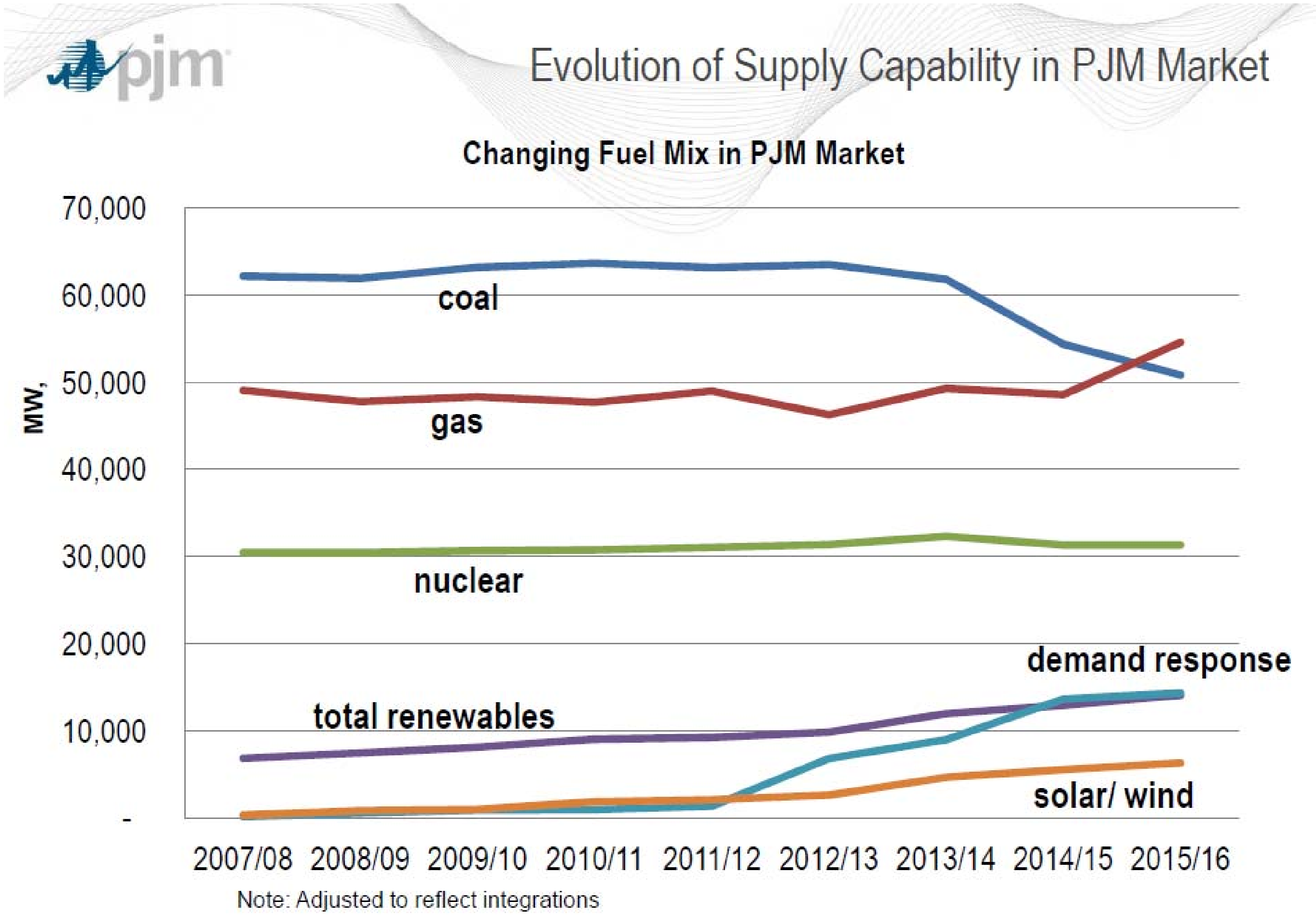


USEIA Data

What Happened Overall in the Northeast



What Happened Overall in the Northeast

Recent low natural gas prices, tied to the availability of shale gas have contributed to a dramatic reduction in air pollution emission rates in New England.

- The northeast had excess combined cycle gas turbine capacity from a building boom in the late 1990s.
- Older coal- and oil-fired boilers have been displaced as those fuels have become more expensive than gas.
- Since 2008, sulfur dioxide emissions have decreased 75%, nitrogen oxides decreased 39%, and carbon dioxide decreased 12%.

Also, price volatility made GTCCs unprofitable in the mid-2000s, and is making coal and oil-fired boilers unprofitable now.