Review of Approach and Assumptions Levelized Cost of New Entrant Peaking Unit

Presentation to NYISO Installed Capacity Working Group

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Topics

- Tariff Requirements
- Technology Screening
- Zones and Localities
- Review of Key Parameters for
  - *Unit Characteristics*
  - *Capital Cost*
  - *O&M Costs*
- Interconnection
- Levelized Cost Analysis

Note: Abbreviations Summary provided on last slide

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Tariff Requirements

- As before, the review assesses the localized levelized cost of a peaking unit
  - *Peaking plant defined as "the unit with technology that results in the lowest fixed costs and highest variable costs among all other units' technology that are economically viable."*
- Analysis also will include combined cycle or other technologies in each locality examined
  - *Combined cycle unit or other generating technology defined as the unit with technology that results in the lowest Demand Curve Reference Point under current conditions, accounting for the amount of capacity excess associated with the technology*
- Objective is to determine whether a technology with more expensive capital cost unit and a lower variable or operating cost would have a lower net cost than the cost of a peaking unit

Proposed Criteria for Screening Technologies

- Can meet environmental requirements
- Commercially available
- Utility scale
- Available to most market participants
- COD no later than Capability Year beginning May 1, 2016
- Has peaking or cycling characteristics
  - *Cycles off during off-peak hours – average run time < 16 hours*
  - *Repeatable on a daily basis*
  - *Starts and achieves minimum load within an hour*
- An incremental addition of 100-400 MWs, depending on technology
  - *Need MWs of at least two generators (CT, ST or RICE driven) to cover common costs*

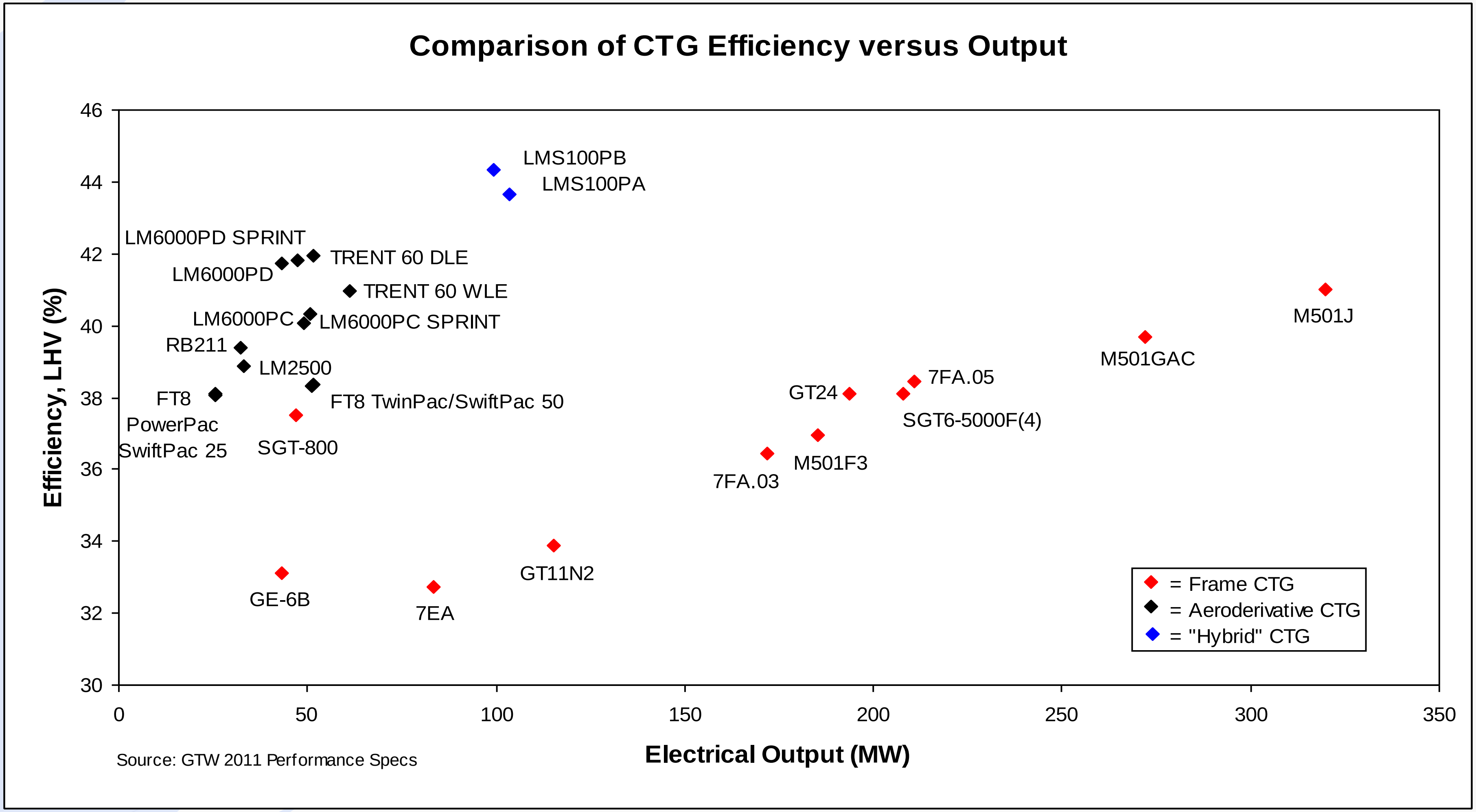
Technology Screening – Initial Observations

- These technologies should not be reviewed in more detail:
  - *Intermittent power resources (wind, solar) due to low Unforced Capacity Percentage in summer (for wind) and winter (for solar).*
  - *Dispatchable renewable technologies (hydropower, biomass, MSW, LFG) because they have limited fuel availability and are not available to most market participants*
  - *Fuel cells and storage technologies because they are not economically viable or available to most market participants (e.g., CAES)*
  - *Nuclear technologies because of long lead times*
  - *Coal technologies because of long lead times, emissions requirements, and commercial status of carbon sequestration and storage technologies*
- Several natural gas technologies have industry proven designs and can meet the criteria:
  - *Simple cycle combustion turbines*
  - *Combined cycle*
  - *Reciprocating internal combustion engines*

Simple Cycle Turbines: Aeroderivatives vs. Frame

- Smaller megawatt output for Aeros makes them conducive for installation in multi unit blocks
- Startup times and ramp rates for Aeros are quicker than Frames
- Maintenance factors for Aeros are not affected by quicker startup times
- Aeros are more efficient and hence have lower exhaust energy
  - *Good for peaking; less common in Combined Cycle application*
  - *Frame is a better for CC application for both performance and cost*
- Aeros are typically more costly than Frame on a $/kW basis
- Aeros and Frames are incorporating features from each other
  - *Frame technology getting incorporated into Aeros (e.g., LMS100)*
  - *Frames incorporating Aero design features (e.g., rapid start options)*

Simple Cycle Turbines



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Combined Cycle Using Frame Machines

- 1x1x1 or 2x2x1 configurations with changes driven by operating needs (peaking and/or cycling operation)
- Integration of Aero Design Features into Frame Machines
  - *Advanced Compressor Technology and Multiple Variable Guidevanes*
  - *Improved Combustion Technologies*
- Improved Cycling Capability
- Rapid Response to Load Following
- Low Load Operation and Remain Emissions Compliant
- Supplemental Firing of HRSG for low $/kW incremental power with reasonable incremental heat rates comparable to simple cycle CT
- Options to Reduce Start Times
  - *100% Capacity Steam Turbine Bypass (potential emissions issues)*
  - *"Flex" designs offered by vendors (e.g., Siemens, GE)*
  - *Auxiliary boiler to keep piping and ST warm and maintain condenser vacuum while CT is offline*

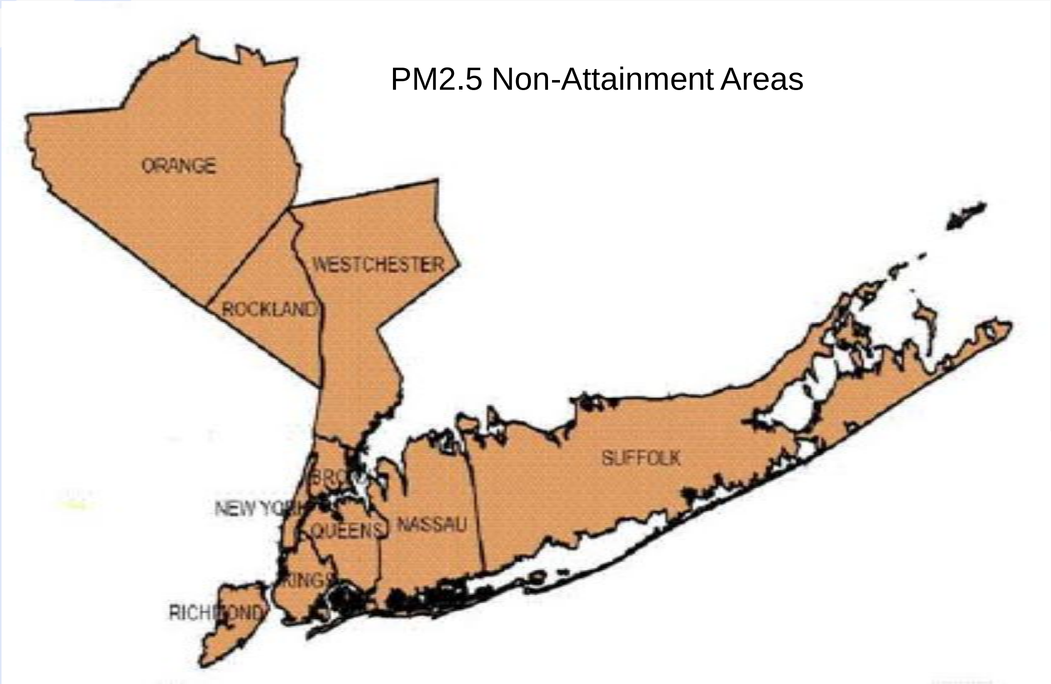
Reciprocating Internal Combustion Engines (RICE)

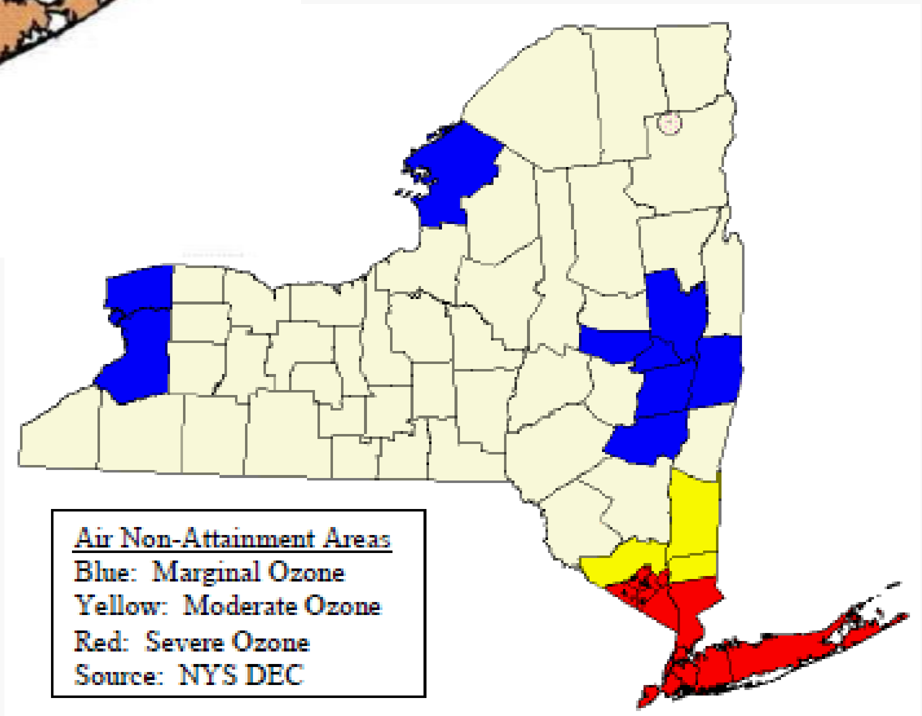
- Gaining popularity for load following (integrating renewables) and peaking service with multiple engines at the site (5 - 20 MW per engine)
- Advantages
  - *Fast startup times*
  - *No minimum operating time*
  - *No degradation per startup*
  - *High part load efficiency*
  - *Capable of multiple daily starts*
  - *Minimal derate due to ambient temperature and elevation*
- Disadvantages
  - *Requires multiple number of units, requiring space*
  - *Noise, requires Building enclosure*
  - *Maintenance*
  - *Emissions if on fuel oil and Modeled Ambient Air Quality Impacts*

Environmental Requirements Simple Cycle and RICE

- Each technology configuration must be evaluated on the basis of total emissions per year by pollutant and then classified as a major or minor source
- Major source thresholds for Simple Cycles and RICE:
  - *250T/yr CO*
  - *100,000T/yr CO_2 (new requirement compared to last DC study)*
  - *100T/yr NO_x (25T/ yr in Severe Ozone Non Attainment Areas)*
  - *50T/yr VOC (25T/ yr in Severe Ozone Non Attainment Areas)*
  - *100T/yr PM_{10}, $PM_{2.5}$ in Severe Ozone Non Attainment Areas*
- Major sources for NO_x must:
  - *Meet LAER, i.e., an SCR, plus emissions offsets at the ratio of 1.15:1 (1.3:1 for Severe), <u>or</u>*
  - *Accept a maximum limit on annual operating hours*

New York Air Non Attainment Areas





Environmental Requirements Simple Cycle and RICE

- If a Simple Cycle or RICE is a major source for CO_2 but not for NOx, it must be further evaluated for PSD
  - *PSD Significance Levels*
    - *NOx: 40T/yr (2.5T/yr for Severe Ozone Non-Attainment Areas)*
    - *CO: 100T/yr*
  - *Major sources that exceed PSD Significance Levels must use BACT (i.e., an SCR for NOx and catalyst for CO)*
- A major source for CO_2 must also evaluate BACT for CO_2
  - *The best remedy for GHG is efficiency, e.g., combined cycle for frame machines instead of simple cycle*
- Likely Results:
  - *Aeroderivatives and RICE technologies will likely need SCR and CO catalyst, possibly with an annual operating hour limit*
  - *Frame Machines will likely need to be configured as combined cycle with SCR and CO catalyst*

Environmental Requirements Combined Cycle

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- Major source thresholds for combined cycle:
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  - *100,000T/yr CO2 (new requirement compared to last DC study)*
  - *100T/yr NOx (25T/ yr in Severe Ozone Non Attainment Areas)*
  - *50T/yr VOC (25T/ yr in Severe Ozone Non Attainment Areas)*
- Same process described for simple cycle applies to combined cycle
- Likely Result: SCR and CO catalyst

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Zones and Localities

- Zones A-E – use Syracuse as proxy
- Zone F – Albany
- Zones G, H and I
  - *May require differentiation by county depending on:*
    - *Environmental requirements (Ozone, PM10, PM2.5 non-attainment)*
    - *SDU costs*
    - *Labor markets*
- Zone J – NYC
- Zone K – Long Island

Unit Characteristics

- Number of units depends on technology
- Greenfield site (brownfield NYC)
- Wet cooling (dry cooling NYC)
- Natural Gas fueled (dual fuel NYC)
- Heat Rate depends on technology
- Water Use, Land requirements depend on number of units and technology
- Emissions Controls depend on technology and environmental requirements
- If a turbine:
  - *Natural Gas Compression (local pressure 200 psig)*
  - *Inlet Air Evaporative Cooling (no inlet air chillers)*

Capital Cost Estimates

- Equipment cost trends
  - *Domestic turbine order volume is down; prices decreasing in last year*
    - *Expectation that orders will increase, but still waiting…*
    - *New model / upgrade introductions to position for growth*
  - *BOP equipment:*
    - *Consolidation of suppliers resulting in higher prices for some items, e.g., fuel conditioning, cooling towers*
    - *Tube manufacturing has moved to China; prices down for equipment using tubing, e.g., air cooled condensers, HRSGs*
  - *Shop labor costs generally rising, but shop space is available and manufacturers need projects*

Capital Cost Estimates

- Labor cost trends
  - *Factors:*
    - *Unit prices*
    - *Labor availability by region / location*
    - *Other projects competing for labor force*
    - *Fees & markups vary with market conditions*
  - *Do not expect high price increases*
- Materials cost trends
  - *Commodity pricing generally holding up*

O&M Cost Estimates

- Fixed O&M—used in levelized cost analysis
  - *Number of staff*
  - *Materials and Contract Services*
  - *A&G*
  - *Site Leasing cost*
  - *Property Taxes*
    - *Tax abatement for peakers in NYC – less than 16 hours per day*
  - *Insurance*

O&M Cost Estimates

- Variable O&M—used in net energy and ancillary service revenue estimates
  - *Overhauls:*
    - *Aeroderivatives: 50,000 factored hours*
    - *Frame units: 48,000 hours or 2,400 factored starts, whichever occurs first*
  - *Fuel costs*
    - *Texas Eastern Transmission Market Area 3 or Transco Zone 6 price*
  - *Fuel transportation costs based on ConEd and National Grid tariffs*
    - *Firm service is not commonly provided due to prohibitive costs*

Interconnection Cost Estimates

- Working with NYISO transmission planners to specify studies to estimate SDU costs by zone/locality
- Will estimate SUF costs using standard open air and GIS designs applicable to each zone

Financial Parameters for Real Levelized Carrying Charges

- Assumptions for cost of capital and for inflation to be provided by NERA
- Separate amortization period for each location per NERA methodology
- Depreciation schedule 15-year MACRS for CTs and 20 years for CC

Abbreviation Summary

- A&G – Administrative & General
- BACT – Best Available Control Technology
- BOP – Balance of Plant
- CAES – Compressed Air Energy Storage
- CC – Combined Cycle
- CO – Carbon Monoxide
- CO_2 – Carbon Dioxide
- COD Commercial Operation Date
- CT – Combustion Turbine
- CTG – Combustion Turbine Generator
- GE – General Electric
- GIS – Gas Insulated Substation
- GHG – Green House Gas
- HRSG – Heat Recovery Steam Generator
- kW – Kilowatt
- LAER – Lowest Achievable Emissions Rate
- LFG – Landfill Gas
- MACRS – Modified Accelerated Cost Recovery System
- MSW – Municipal Solid Waste
- MW – Megawatt
- NOx – Nitrogen Oxides
- NYC – New York City
- NYS DEC – New York State Department of Environment and Conservation
- O&M – Operations and Maintenance
- PM – Particulate Matter
- PSD - Prevention of Significant Deterioration
- RICE- Reciprocating Internal Combustion Engine
- SCR – Selective Catalytic Reduction
- SUF – System Upgrade Facilities
- SDU – System Deliverability Upgrades
- ST – Steam Turbine
- T/yr – Tons per year
- VOC – Volatile Organic Compounds