APPENDIX H. DETERMINATION OF LIQUID FUEL INVENTORY LEVELS

General

In LAI's view there is no "right" amount of backup fuel inventory or storage tank capacity for a dual-fuel capable power plant. Optimizing tank size and fuel inventory requires multi-faceted mathematical analysis of PPA specific reliability goals, weather conditions, plant-specific criteria and transportation replenishment logistics that are beyond the overall scope of the Target 4 research goals and objectives. LAI formulated the tank "bogie" for distillate liquid fuel, usually ULSD, which would be utilized by combustion turbines in SC or CC applications as an alternate or back-up fuel.[1] In developing the "bogie" for constrained locations for PPA review, LAI has relied on the results of the Target 2 analysis, but then considered other factors affecting the PPAs'ability to realize the benefits of fuel assurance through dual fuel capability in lieu of incremental firm transportation. Decisions regarding tank capacity and inventory management are influenced by a wide range of factors, including grid reliability. Reliability is the principal driver for traditional regulated cost-of-service utilities such as TVA and IESO, and for competitive markets developing market rules and penalties to promote generator availability when called on by PPAs in the day-ahead or real-time energy market. Owners' decisions are also driven by expected return on investment, tempered by the impacts of low-probability, high-impact events. In performing this analysis, LAI did not address specific financial risk factors attributable to PJM's Capacity Performance proposal or ISO-NE's two-part settlement mechanism designed to induce generator performance.

For the purposes of this analysis, LAI set a tank capacity/target inventory level for each power plant location selected by the PPAs based on a consideration of the pipeline constraint frequency-duration characteristics defined in Target 2 applicable to the location, along with an assumed winter peak period operation profile (5 days/week x 16 hours/day for CC, 5x8 for SC) and identifiable characteristics of the local ULSD delivery infrastructure.[2]

Plant Owner Considerations

The objective of a plant owner is to optimize cash flows consistent with system reliability and fuel assurance goals. In establishing tank size and/or target inventory level for backup fuel, owners are likely to consider the following list of factors:

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[1] An alternative fuel assurance strategy for generators in NEMA / Boston and SEMA would be a seasonal peak arrangement for the purchase and storage of one or more cargoes of LNG at the Suez Distrigas terminal in Everett. This strategy would surely necessitate the participation of multiple generators to overcome diseconomy of scale problems. This analysis is limited to ULSD as a back-up fuel for new SC or CC generators, and does not include LNG alternatives. Logistics for existing dual-fuel capable plants, including steam plants using residual oil as backup/alternative fuel, are addressed in Section 2 of the report.

[2] The operation profile of the CC is based on the typical dispatch regime of a new CC observed in AURORAxmp, as well as a simplifying assumption for the SC. The 5 x 8 operation profile of the SC accounts for the real option value of an efficient, quick-start SC in the DA and RT markets. The profile determines the potential daily ULSD consumption during severe winter conditions, relative to the maximum daily quantity. That these profiles match the profiles used to quantify annual average natural gas consumption to calculate a credit for avoided IT service is purely coincidental.

1. Frequency and duration of pipeline limitations on the scheduling of natural gas during the peak heating season, January, February and December. To the extent non-firm shippers are exposed to curtailments or interruptions, nominations in accord with the existing or anticipated changes to NAESB scheduling protocols may still limit a generator's ability to obtain all or a portion of the daily fuel requirements to meet the expected dispatch regime in the day-ahead or real-time market. Curtailment can be characterized by both frequency and duration of curtailment events. Even without actual curtailment, pipeline constraints can make it difficult to schedule gas delivery to match ISO/RTO required dispatch profiles. Under usual wintertime operating conditions, there are no restrictions on the scheduling of natural gas if the generator holds a firm entitlement equal to or approximately equal to the MDQ. However, to the extent the pipeline posts an Operational Flow Order during a critical event, the generator's ability to schedule natural gas during such an event may be limited due to enforcement of the ratable take tariff provisions.

2. Economics of operation on back-up fuel. Owners would consider what fraction of the winter days is operation on backup fuel likely to be "in-the-money" relative to prevailing market energy prices? To what extent are such days likely to be consecutive? How many hours of equivalent full load operation per day can be expected when dispatched on backup fuel?

3. Delivery lag time for backup fuel delivery. How many hours are likely to pass between ordering replenishment service from a supplier and the arrival of first deliveries? Depending on the location and size of available transportation fleets (truck or barge), this lag could vary between one day or less and several days or more. Under normal road conditions, the lag time for initiation of delivery by truck is typically about one day. Barge deliveries typically have longer lead times but are aided somewhat by the much larger volume of deliveries (600,000 to 1 million gallons) as compared with truck (typically around 10,000 gallons).

4. Impact of severe weather events on backup fuel delivery capacity. To what extent can severe winter weather events, particularly snow (for truck delivery) or severe cold (for barge delivery) slow down or stop a contracted delivery stream to the plant? During and in the aftermath of a severe storm, truck drivers may not be able to reach oil terminals due to lags in plowing and sanding secondary and tertiary roads for 3 or more consecutive days. Barge deliveries may be faced with limitations on movements due to marine waterway icing.

5. Impact of failure to deliver dispatched energy or to offer into market due to unavailability of fuel on plant net revenues. In particular, does failure to generate during a fuel constraint event result in a significant loss of capacity revenue or a penalty with similar effect?

Existing dual-fuel capable plants have distillate fuel tank capacities that can range depending on location and specific plant conditions from one day of full-load operation to five days or more, as shown in Section 2 of the report.

Procedure for Determining Tank Capacity/Target Inventory Levels

Based on a goal of fuel assurance roughly equivalent to firm transportation for natural gas, LAI utilized the following approach for each of the identified locations to set an inventory level, measured in days of equivalent full load fuel burn.

1. Identification of the Relevant Constraint – The appropriate constrained pipeline segment for the location was selected from among those described in Sections 6 and 8 of the Target 2 report for RGDS S0, Winter 2018. This identification provides the fraction of days in the season in which some level of affected generation is likely to occur, along with the extent to which such days are clustered over consecutive day events. Inspection of the Frequency-Duration (F-D) results by pipeline in the recommended constrained region results in a characterization of frequency duration as "high," "moderate," or "low."

2. Identification of the Relevant ULSD Supplier – The closest substantial distillate fuel terminal was identified for each location. The time lag to initiate deliveries upon notification, normal round trip times for trucks, *etc.*, was defined as was a maximum daily delivery rate, based on the normal daily fuel burn.

3. Identification of ULSD Delivery Constraint Events – The likelihood and extent of events which could slow down or stop deliveries for more than a 24 hour period was evaluated, based on the locations of the depot, the plant location, and the intervening route. This constraint was defined as the time that would be required to clear roads from a severe snow fall. Given the development of the transportation market for ULSD, which has resulted in large refinery runs and widespread storage and distribution facilities, there should be fewer winter availability and transportation constraints for ULSD going forward as compared with traditional No. 2 fuel oil supplies observed in the past.

4. Set the tank capacity/target inventory level per the following equation:

   TIL = (DPC + DLC + DCC) * EDF

   where TIL = Target Inventory Level, days of Full Load Equivalent (FLE) Fuel Burn
   DPC = Demand Persistence Component, days
   = 0 days for no identified constraint
   = 1 day for "Low" F-D of applicable constraint
   = 2 days for "Moderate" F-D
   = 3 days for "High" F-D
   DLC = Delivery Lag Component, days
   DCC = Delivery Constraint Component, days
   = Estimated max consecutive days of ULSD delivery constraint
   EDF = Equivalent Dispatch Factor
   = (5 x 16) / (7 x 24) = 0.476 for CC plants
   = (5 x 8) / (7 x 24) = 0.238 for SC plants

Example 1 (Truck Delivery):

For a location linked to a pipeline segment with a "moderate" constraint F-D pattern, a ULSD delivery lag of 24 hours, and a ULSD delivery constraint of 2 days to clear roads after a major snowstorm, the target inventory levels for CC and SC applications would be as follows:

TIL for CC = (2 + 24 / 24 + 2) * 0.476 = 2.38 days FLE

TIL for SC = (2 + 24 / 24 + 2) * 0.238 = 1.19 days FLE

Example 2 (Barge Delivery):

For a location with barge delivery facilities linked to a pipeline segment with a "high" constraint frequency-duration pattern, a ULSD delivery lag of 7 days, and a ULSD delivery constraint of 10 days to clear ice in a major cold spell, the target inventory levels for CC and SC applications would be as follows:

TIL for CC = (3 + 7 + 10) * 0.476 = 9.52 days FLE

TIL for SC = (3 + 7 + 10) * 0.238 = 4.76 days FLE

Note that, in the case of barge delivery, the tank capacity would be increased by the volume of one bargeload to facilitate unloading and to avoid demurrage charges.