Metering Fundamentals

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Accounting & Billing Workshop

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Remote Learning

Session Objectives

- Identify the role of a Meter Authority
- Name the two types of Meter Authorities
- State the meaning of the following terms:
  - Control Computer System
  - Telemetry
  - Revenue Quality Metering
  - Revenue Quality Real-Time Metering
  - Performance Tracking System (PTS) Data
  - Sub-Zone
  - Settlement Data Exchange (SDX)

Session Objectives cont'd

- Identify two types of metering devices used to measure and record energy usage and instantaneous demand
- Describe how meter data from real-time and hourly revenue meters are used in financial settlements

Metering Fundamentals: Roles

Metering Fundamentals

- Meter Authority (MA):
  - An entity that is responsible for the calibration, maintenance, operation, and reporting of metered data from an electric revenue meter used in the wholesale electricity markets administered by the NYISO (*i.e., a Member Systems or Meter Services Entity*)

Metering Fundamentals

- Member Systems
  - The eight Transmission Owners that comprised the membership of the New York Power Pool, which are:
    - Central Hudson Gas & Electric Corporation
    - Consolidated Edison Company of New York, Inc.
    - New York State Electric & Gas Corporation
    - Niagara Mohawk Power Corporation d/b/a National Grid
    - Orange and Rockland Utilities, Inc.
    - Rochester Gas and Electric Corporation
    - Power Authority of the State of New York
    - Long Island Lighting Company d/b/a Long Island Power Authority

Metering Fundamentals

- Meter Services Entity
  - An entity registered with the ISO and authorized to provide metering and meter data services, as applicable to:
    - Demand Reduction Providers
    - DSASP Providers
    - Aggregators
    - Responsible Interface Parties (RIPs) or Curtailment Service Providers (CSPs)

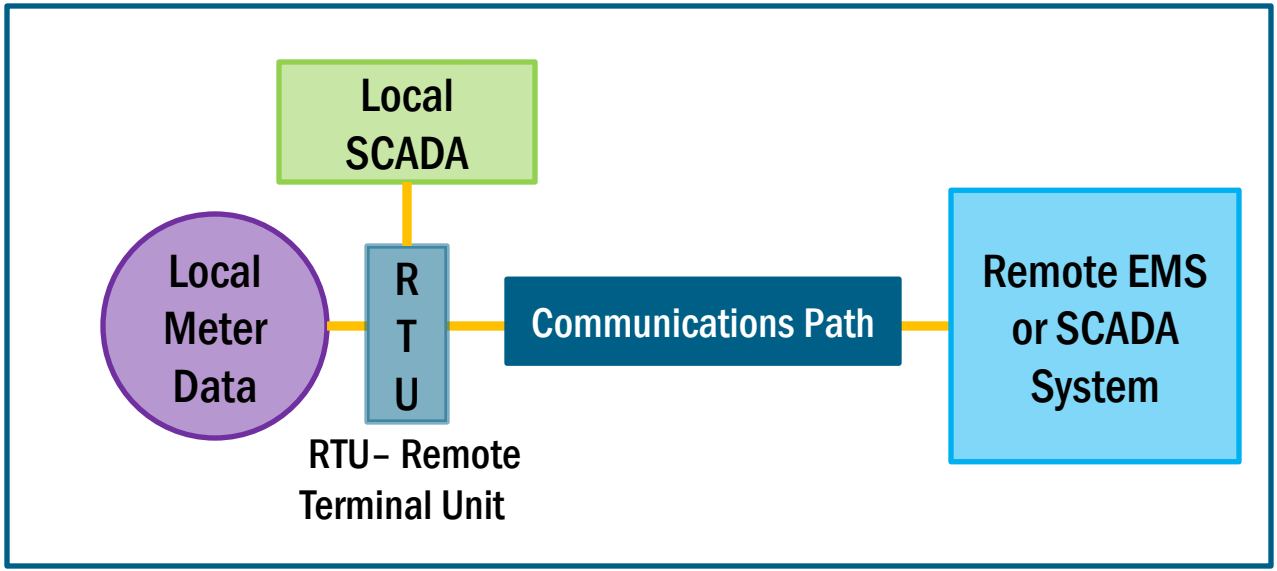
Metering Fundamentals: Terms

Metering Fundamentals

- Control Computer System
  - The real-time computer used to monitor and control the power system
  - These systems are often referred to as SCADA (supervisory control and data acquisition) systems or;
    - SCADA/AGC (SCADA automatic generation control) systems
    - Energy Management Systems (EMS)
  - Individual Transmission Owners may call their systems by other names, such as Power Control System

Metering Fundamentals

- Telemetry
  - Process of collecting meter data and transmitting the data over a communications path to another location



Metering Fundamentals

- Revenue Quality Metering
  - Use of Electric Revenue Metering Systems to provide data for energy billing purpose
  - The components of these systems are approved by both the TO and the New York State (NYS) Public Service Commission (PSC) for revenue settlements
- Revenue Quality Real-Time Metering
  - An accurate metering system that satisfies American National Standards Institute (ANSI) C12 requirements for electrical energy billing purposes
  - Approved for use by both the TO and the NYS PSC

Metering Fundamentals

- Performance Tracking System (PTS) Data
  - Actual energy injections are measured in real-time and telemetered to the NYISO typically every six seconds
  - Real-time telemetry, which is a component of the real-time settlement, and is used by the NYISO for initial billing and final settlement if no other values are available
  - NYISO uses both the PTS data and the hourly MWh data reported by the MA to compute real-time interval level and hourly billing

Metering Fundamentals

- Sub-Zone
  - Sub-region of a New York Control Area (NYCA) Locational-Based Marginal Pricing (LBMP) zone controlled by a single transmission owner
  - Sub-zones are defined and metered to allow allocation of energy to load

Metering Fundamentals

- Settlement Data Exchange (SDX)
  - A web-enabled application for the upload and download query functions related to hourly tie line, generation, Sub-Zone, and load bus data
- Metering Application Programming Interface (API)
  - Must be used by Meter Authorities (MA) and Metering Services Entities (MSE) when submitting hourly revenue grade metering for all Aggregations
    - Additionally allows for retrieval of hourly revenue grade metering and calculated sub-zone load data
  - May be used by traditional generators, storage resources, and tie lines

Meters Used for Settlements

Types of Electrical Metering

- Instantaneous Meter (Demand Meter)
  - A meter designed to display/record the real-time or instantaneous value of power (kW or MW)
  - Typically, not revenue grade metering
  - Meter reading represents real-time energy being produced or consumed, varies with changes

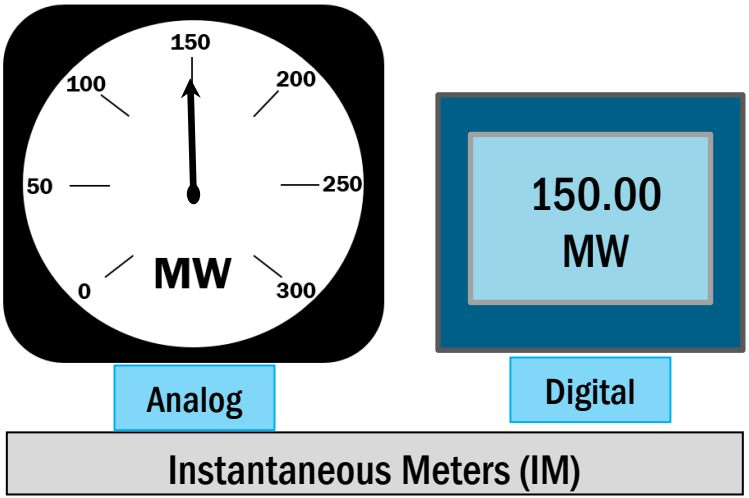


Illustration Only

Types of Electrical Meters

New York ISO
Independent System Operator

- Watt-hour Revenue Meter
  - Watt-hour meters are often used for billing purposes
  - Meter indicates the amount of energy consumed over time
  - The dials record the total usage of kWh
  - Some meters are digital or a combination of mechanical and digital
  - Not all watt-hour meters have a time stamp to indicate usage per a set time-period (concept of interval or time of use)

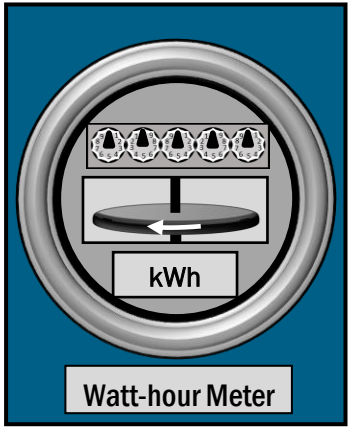
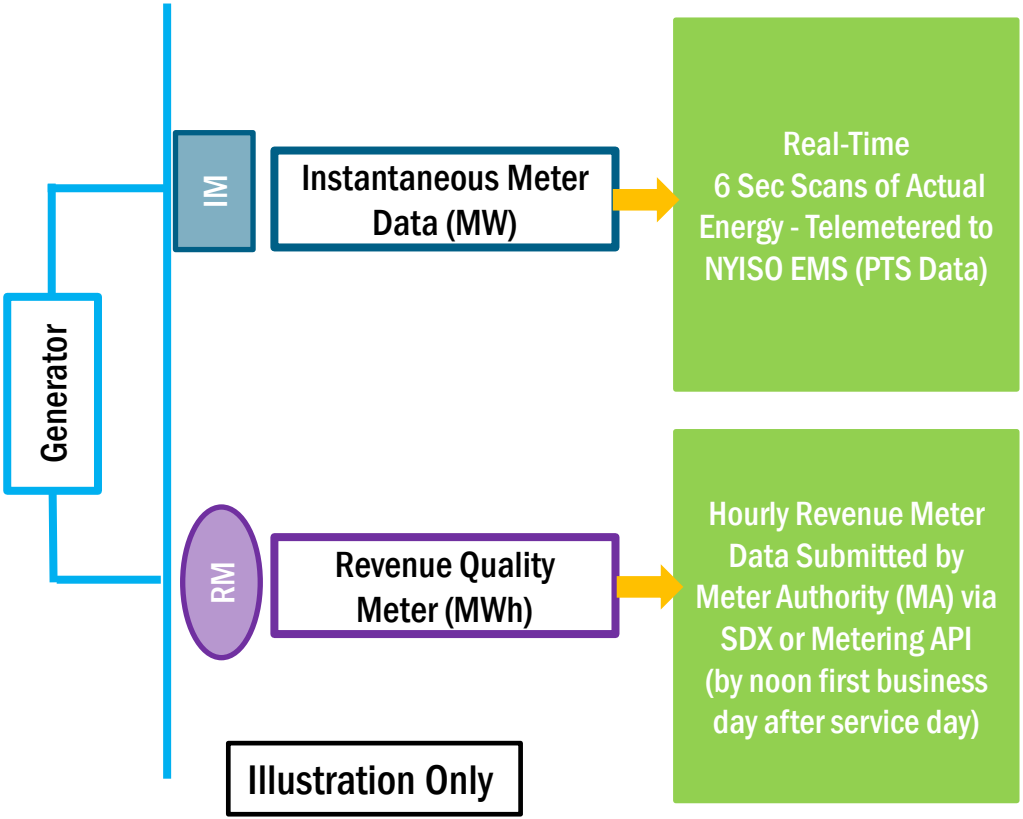
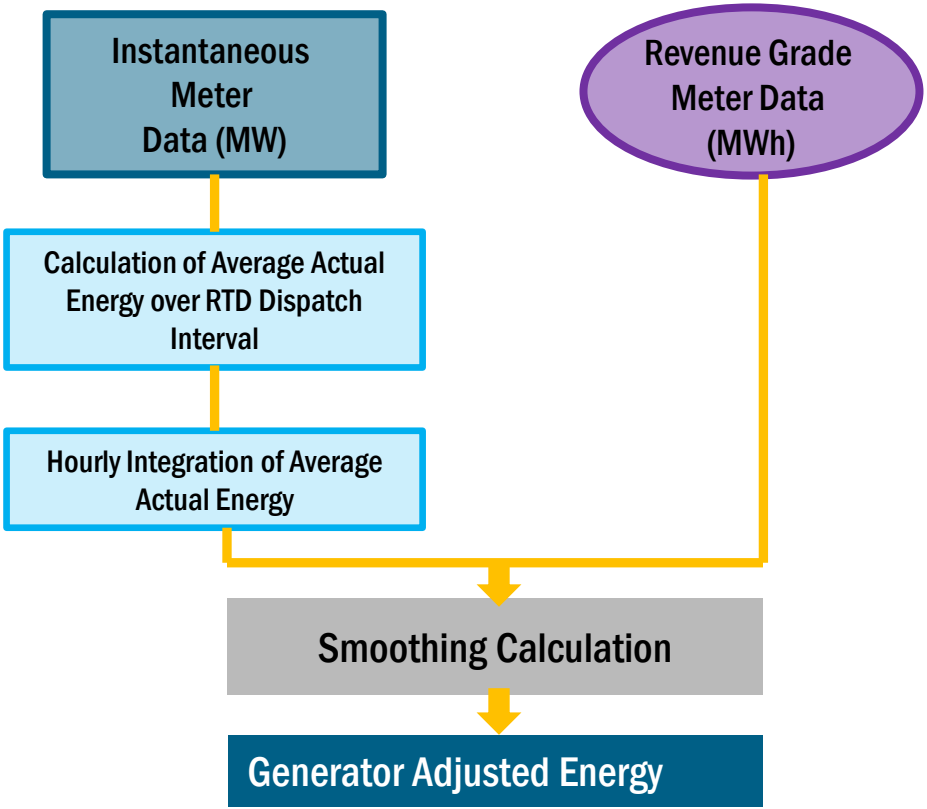


Illustration Only

Meters for Settlement - Generators



Adjustment of Actual Energy-Generator



Calculation of Gen Average Actual Energy Over RTD Interval

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Independent System Operator

Time	MW
01:00:00	10
01:00:06	10
01:00:12	10.1
01:00:18	10.2
01:00:24	10.1
01:00:30	10
01:00:36	10.2
01:00:42	10
01:00:48	9.9
01:00:54	10

Time	MW
01:01:00	9.9
01:01:06	10
01:01:12	10.0
01:01:18	9.9
01:01:24	10
01:01:30	10
01:01:36	9.9
01:01:42	10
01:01:48	10
01:01:54	10

Time	MW
01:02:00	10
01:02:06	10
01:02:12	10.1
01:02:18	10.2
01:02:24	10.1
01:02:30	10
01:02:36	9.9
01:02:42	10
01:02:48	10
01:02:54	10.1

Time	MW
01:03:00	10
01:03:06	10
01:03:12	9.9
01:03:18	10
01:03:24	10.1
01:03:30	10
01:03:36	10.1
01:03:42	10
01:03:48	9.9
01:03:54	10

Time	MW
01:04:00	10
01:04:06	10
01:04:12	10.1
01:04:18	10
01:04:24	9.9
01:04:30	9.8
01:04:36	9.9
01:04:42	10
01:04:48	10
01:04:54	10

Average Actual Energy over RTD Interval = 10.0060 MW

Hourly Integration of the Generators Average Actual Energy

Date Time	Gen Average Actual Energy (MW) for RTD
08/19/2018 01:00	10.0060
08/19/2018 01:05	10.0040
08/19/2018 01:10	10.0045
08/19/2018 01:15	10.0000
08/19/2018 01:20	10.0010
08/19/2018 01:25	10.0000
08/19/2018 01:30	9.9990
08/19/2018 01:35	10.0001
08/19/2018 01:40	10.0000
08/19/2018 01:45	10.0010
08/19/2018 01:50	10.0000
08/19/2018 01:55	10.0020
	Average = 10.0015

Computing Gen Adjusted Energy

$$\text{Generator Adjusted Energy} = \text{Generator Average Actual Energy for RTD Interval} \times \frac{\text{Generator Hourly Revenue Meter Energy}}{\text{Hourly Integration of the Generators Average Actual Energy *}}$$

* Value is time-weighted based on RTD Interval length

Generator Adjusted Energy

Date Time	Gen Average Actual Energy (MW) for RTD	Gen Rev. Meter Energy (MW)	Gen Adjusted Energy (MW)
08/19/2018 01:00	10.0060	10.0010	10.0055
08/19/2018 01:05	10.0040	10.0010	
08/19/2018 01:10	10.0045	10.0010	
08/19/2018 01:15	10.0000	10.0010	
08/19/2018 01:20	10.0010	10.0010	
08/19/2018 01:25	10.0000	10.0010	
08/19/2018 01:30	9.9990	10.0010	
08/19/2018 01:35	10.0001	10.0010	
08/19/2018 01:40	10.0000	10.0010	
08/19/2018 01:45	10.0010	10.0010	
08/19/2018 01:50	10.0000	10.0010	
08/19/2018 01:55	10.0020	10.0010	
	Average = 10.0015		

$$10.0060 \times \frac{10.0010}{10.0015}$$

Generator Adjusted Energy

New York ISO
Independent System Operator

Date Time	Gen Average Actual Energy (MW) for RTD	Gen Rev. Meter Energy (MW)	Gen Adjusted Energy (MW) *
08/19/2018 01:00	10.0060	10.0010	10.0055
08/19/2018 01:05	10.0040	10.0010	10.0035
08/19/2018 01:10	10.0045	10.0010	10.0040
08/19/2018 01:15	10.0000	10.0010	9.9995
08/19/2018 01:20	10.0010	10.0010	10.0005
08/19/2018 01:25	10.0000	10.0010	9.9995
08/19/2018 01:30	9.9990	10.0010	9.9985
08/19/2018 01:35	10.0001	10.0010	9.9996
08/19/2018 01:40	10.0000	10.0010	9.9995
08/19/2018 01:45	10.0010	10.0010	10.0005
08/19/2018 01:50	10.0000	10.0010	9.9995
08/19/2018 01:55	10.0020	10.0010	10.0015
	Average = 10.0015		

* The Gen Adjusted Energy will be a billing determinant in the Balancing Market Energy Settlements

Hourly Integration of the Generators Adjusted Energy – Example 1

Date Time	Gen Adjusted Energy (MW) *	Length of RTD Interval/3600	Energy injected per Dispatch Interval
08/19/2018 01:00	10.0055	300/3600	0.833792
08/19/2018 01:05	10.0035	300/3600	0.833625
08/19/2018 01:10	10.0040	300/3600	0.833667
08/19/2018 01:15	9.9995	300/3600	0.833292
08/19/2018 01:20	10.0005	300/3600	0.833375
08/19/2018 01:25	9.9995	300/3600	0.833292
08/19/2018 01:30	9.9985	300/3600	0.833208
08/19/2018 01:35	9.9996	300/3600	0.8333
08/19/2018 01:40	9.9995	300/3600	0.833292
08/19/2018 01:45	10.0005	300/3600	0.833375
08/19/2018 01:50	9.9995	300/3600	0.833292
08/19/2018 01:55	10.0015	300/3600	0.833458
	Average = 10.0010		Sum = 10.0010

Note: If the RTD Intervals are all the same, 5 Minutes (300s), then the Average = $\sum$

Hourly Integration of the Generators Adjusted Energy – Example 2

Date Time	Gen Adjusted Energy (MW) *	Length of RTD Interval/3600	Energy injected per Dispatch Interval
08/19/2018 01:00	10.0055	300/3600	0.833792
08/19/2018 01:05	10.0035	300/3600	0.833625
08/19/2018 01:06	10.0040	60/3600	0.166733
08/19/2018 01:15	9.9995	540/3600	1.499925
08/19/2018 01:20	10.0005	300/3600	0.833375
08/19/2018 01:25	9.9995	300/3600	0.833292
08/19/2018 01:30	9.9985	300/3600	0.833208
08/19/2018 01:35	9.9996	300/3600	0.8333
08/19/2018 01:40	9.9995	300/3600	0.833292
08/19/2018 01:45	10.0005	300/3600	0.833375
08/19/2018 01:50	9.9995	300/3600	0.833292
08/19/2018 01:55	10.0015	300/3600	0.833458
	Non-time weighted Average = 10.0010	X	Sum = 10.0007

Note: If the RTD Intervals are not all the same, then the Average ≠ ∑

Metering Requirements for Energy Storage Resources (ESRs)

- Metering Requirements
  - Provide direct metering regardless of physical location
    - Meters must:
      - Be approved by Metering Authority
      - Provide revenue-quality metering information
      - Provide six-second telemetry
      - Comply with minimum acceptable accuracy standards
  - Submit dual channel hourly meter data
    - Separate fields for Injection MW and Withdrawal MW vs. single net MW value
    - Results in less distortion of values
  - Provide Energy Level (MWh) telemetry in RT

ESR Generator Adjusted Energy

- Example:

Dual Channel Metering

	RTD Avg Actual Injection MW	RTD Avg Actual Withdrawal MW	RTD Adjusted Injection MW	RTD Adjusted Withdrawal MW	Final Adjusted MW
:00	10	0	10.4854	0.0000	10.4854
:05	10	0	10.4854	0.0000	10.4854
:10	10	0	10.4854	0.0000	10.4854
:15	10	0	10.4854	0.0000	10.4854
:20	10	0	10.4854	0.0000	10.4854
:25	1.5	-2	1.5728	-1.9024	-0.3296
:30	0	-5	0	-4.7561	-4.7561
:35	0	-6	0	-5.7073	-5.7073
:40	0	-7	0	-6.6585	-6.6585
:45	0	-7	0	-6.6585	-6.6585
:50	0	-7	0	-6.6585	-6.6585
:55	0	-7	0	-6.6585	-6.6585
	4.2917	-3.4167	4.5000	-3.2500	1.2500

Revenue Meter MWH	4.5000	-3.2500
Adjustment Ratio	1.0485	0.9512

VS.

Single Net Meter

	RTD Avg Actual MW	RTD Adjusted MW
:00	10	14.2857
:05	10	14.2857
:10	10	14.2857
:15	10	14.2857
:20	10	14.2857
:25	-0.5	-0.7143
:30	-5	-7.1429
:35	-6	-8.5714
:40	-7	-10.0000
:45	-7	-10.0000
:50	-7	-10.0000
:55	-7	-10.0000
	0.8750	1.2500

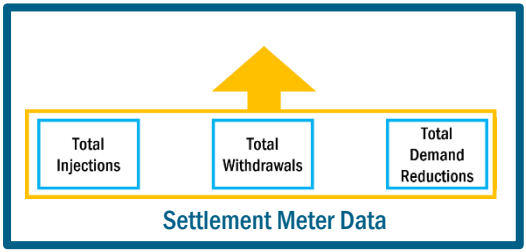
Revenue Meter MWH	1.2500
Adjustment Ratio	1.4286

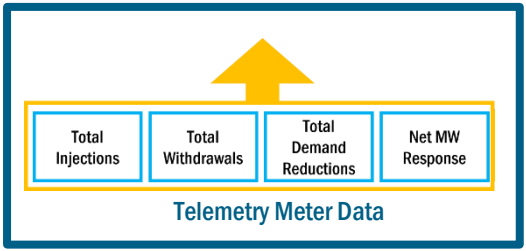
Metering for DER Participation Model

- Aggregation performance and settlement are administered at the Aggregation-level
  - NYISO does not settle Energy injections, withdrawals, or Demand Reductions of the individual DER comprising an Aggregation
  - Note: The revenue quality meters are on the DER
    - Aggregation settlement data is the sum of the revenue meters for each response type (injection, withdrawal, Demand Reduction)
- Three-channel revenue quality metering (RQM) data required by NYISO for settlement from all individual DER in the Aggregation
  - Energy Injections
  - Energy Withdrawals (when the Aggregation contains at least one Withdrawal-Eligible Generator), and
  - Demand Reductions

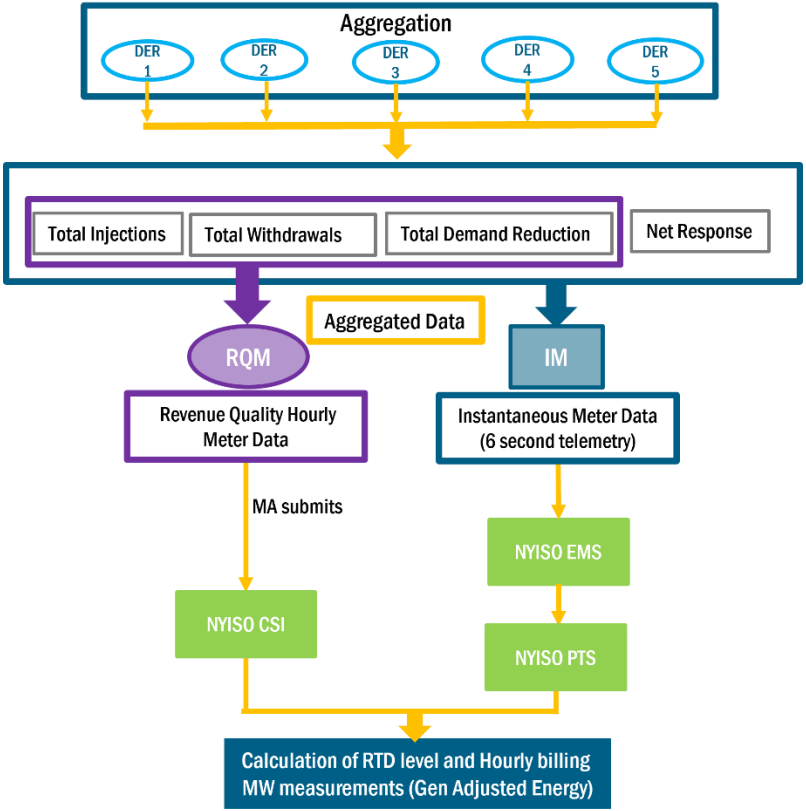
Types of Metering Data - Aggregations

- RQM data required by the NYISO for settlement includes the following channels: Energy Injections, Energy Withdrawals (when the Aggregation contains at least one Withdrawal-Eligible Generator), and Demand Reductions of all individual DER facilities in the Aggregation
- Total Injections: Aggregate of all Injections of energy into grid/wholesale markets by all injecting facilities in Aggregation
- Total Withdrawals: Aggregate of all Withdrawals of energy from the grid used to charge one or more ESR facilities for later injection back into the grid
- Total Demand Reductions: Reductions in load measured by comparing actual load relative to a calculated baseline value (for Demand Side Resources part of DER Aggregation)
- Total Response: Net of the above 3 channels (For Telemetry purposes only)

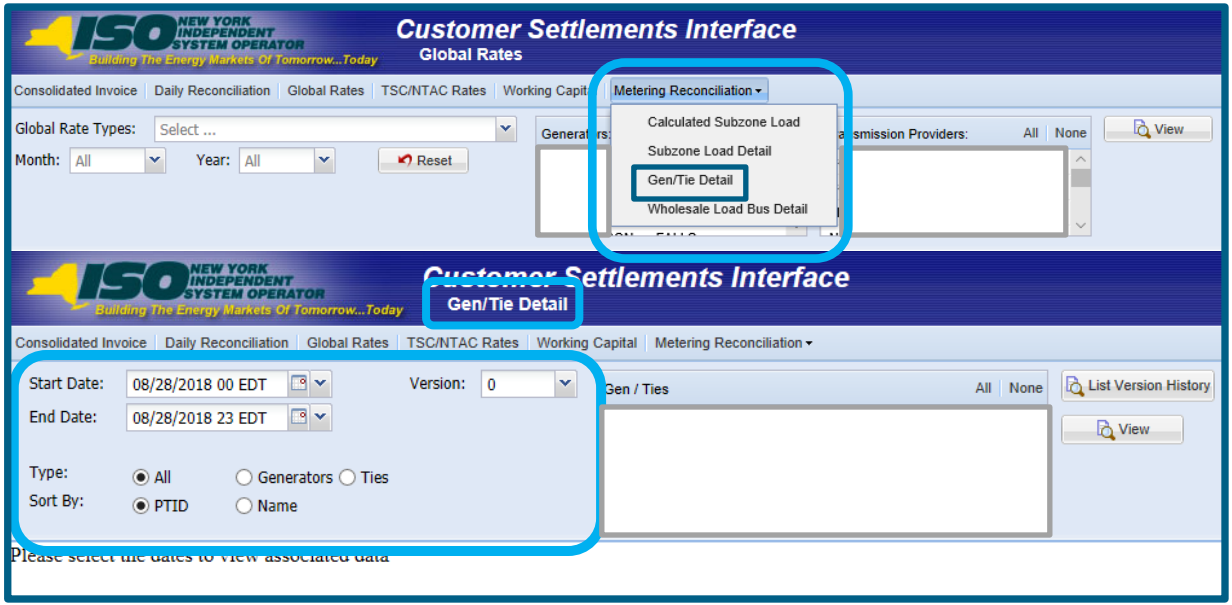




Metering for DER Participation Model- Schematic

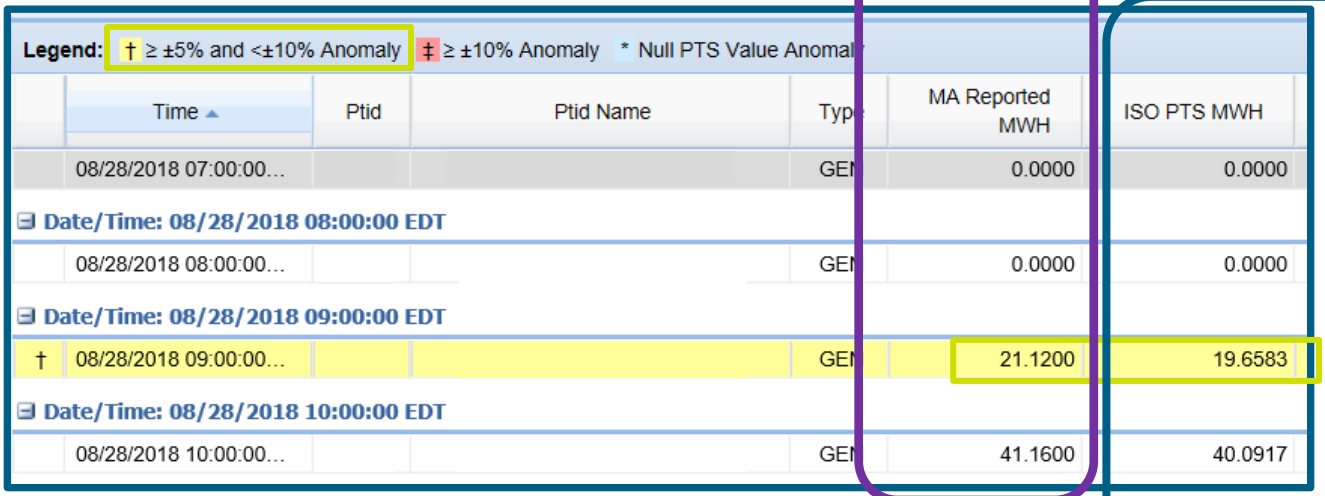


Meter Data in CSI



Meter Data in CSI

Hourly Revenue Meter Data submitted by MA through SDX



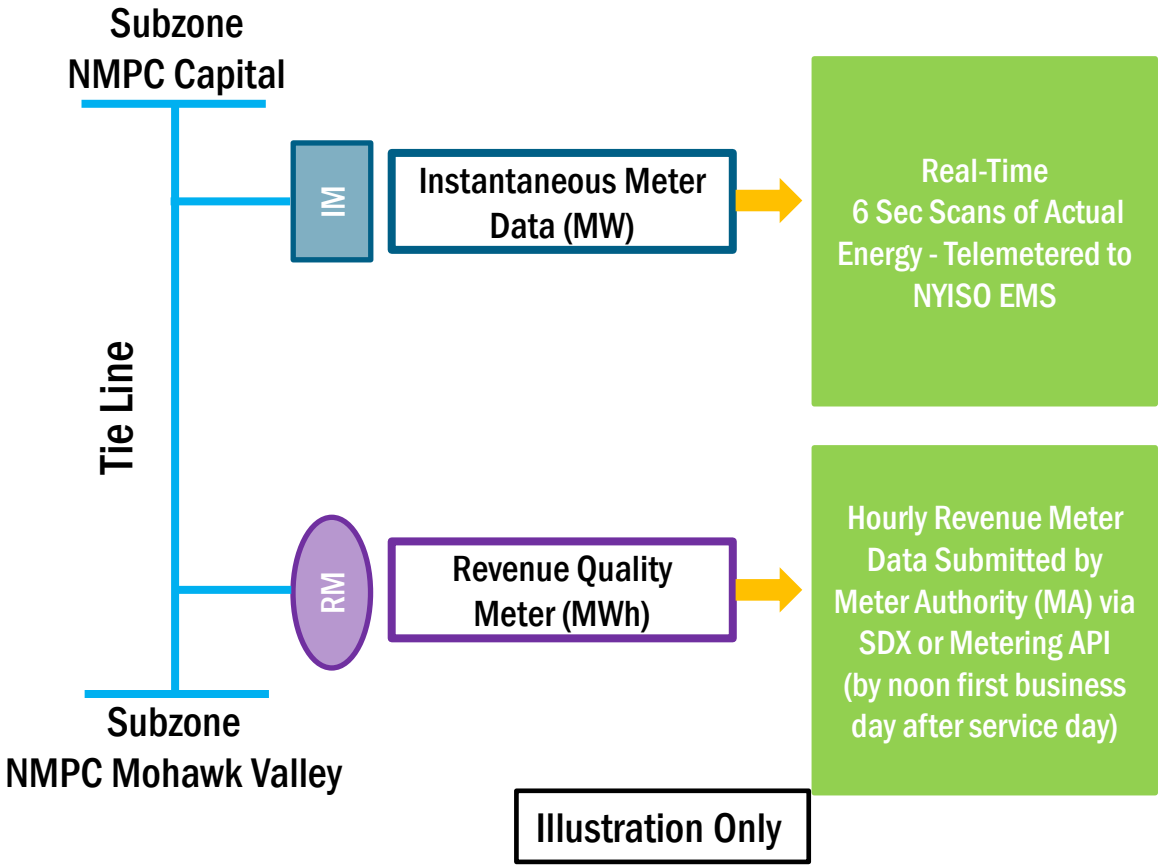
Legend: † ≥ ±5% and <±10% Anomaly ‡ ≥ ±10% Anomaly * Null PTS Value Anomal

	Time	Ptid	Ptid Name	Type	MA Reported MWH	ISO PTS MWH
	08/28/2018 07:00:00...			GEN	0.0000	0.0000
	Date/Time: 08/28/2018 08:00:00 EDT					
	08/28/2018 08:00:00...			GEN	0.0000	0.0000
	Date/Time: 08/28/2018 09:00:00 EDT					
†	08/28/2018 09:00:00...			GEN	21.1200	19.6583
	Date/Time: 08/28/2018 10:00:00 EDT					
	08/28/2018 10:00:00...			GEN	41.1600	40.0917

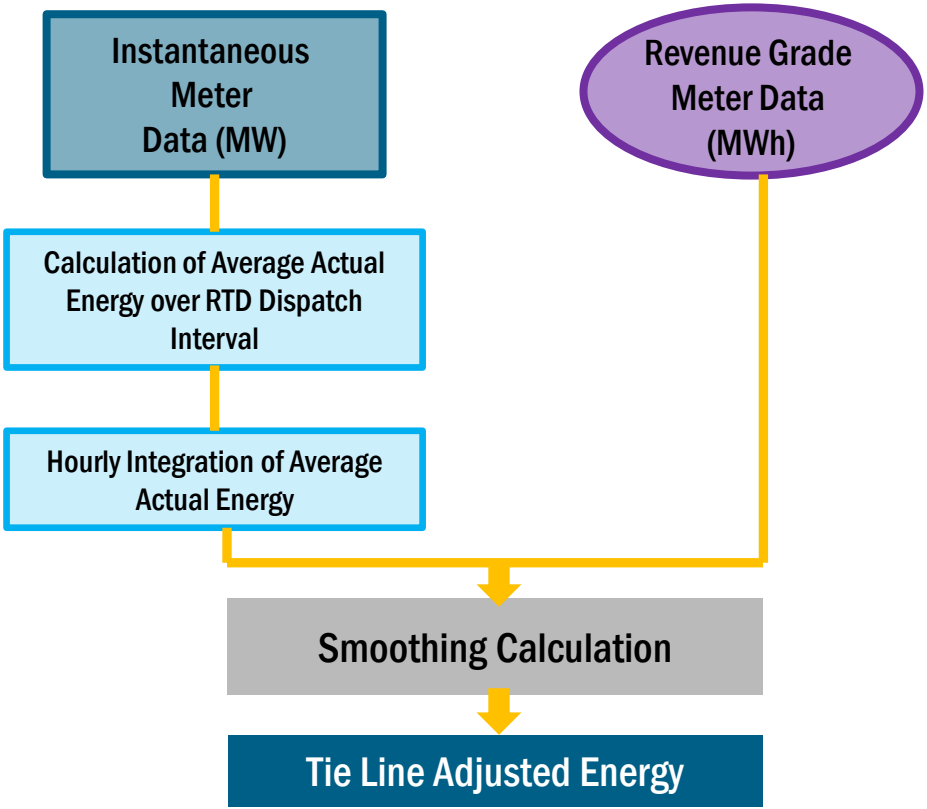
Hourly Integration of the Generators Average Actual Energy from Real Time Metering

Estimating Sub-Zonal Load

Meters for Settlement – Tie-Lines

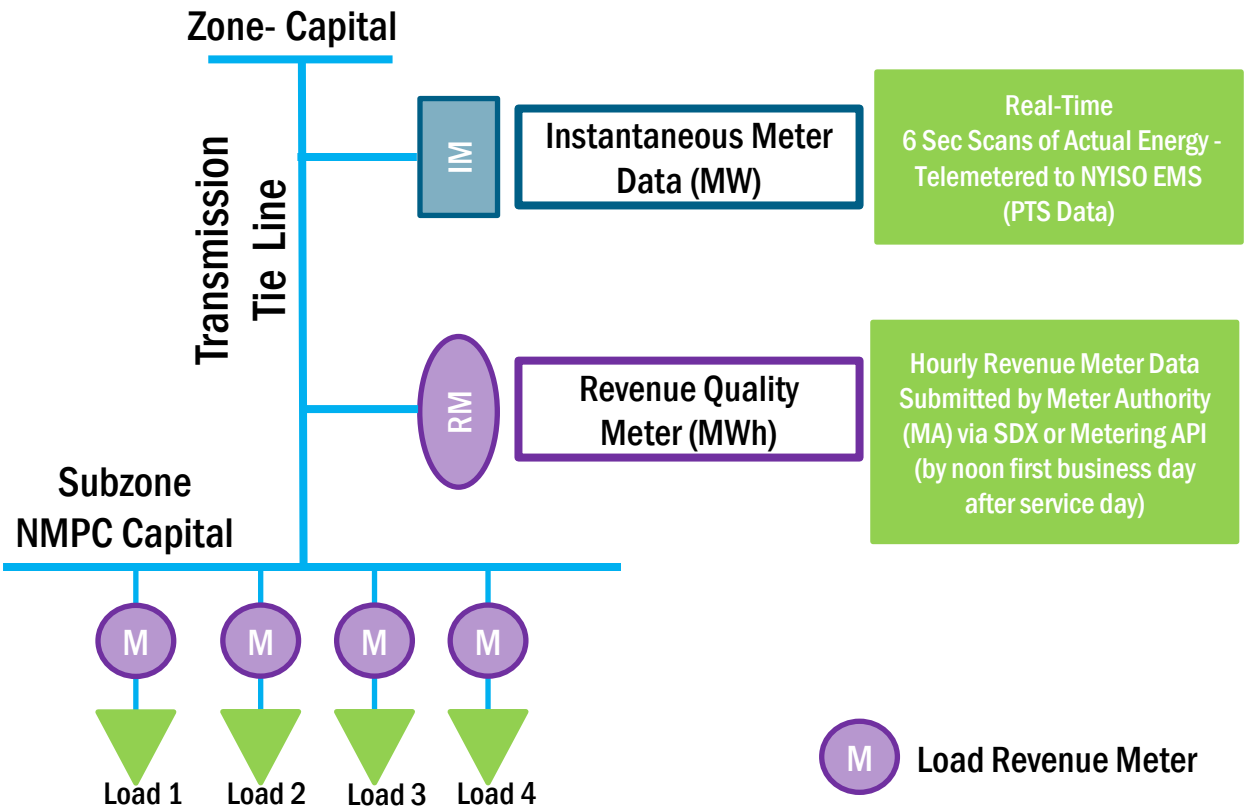


Adjustment of Actual Energy- Tie Line



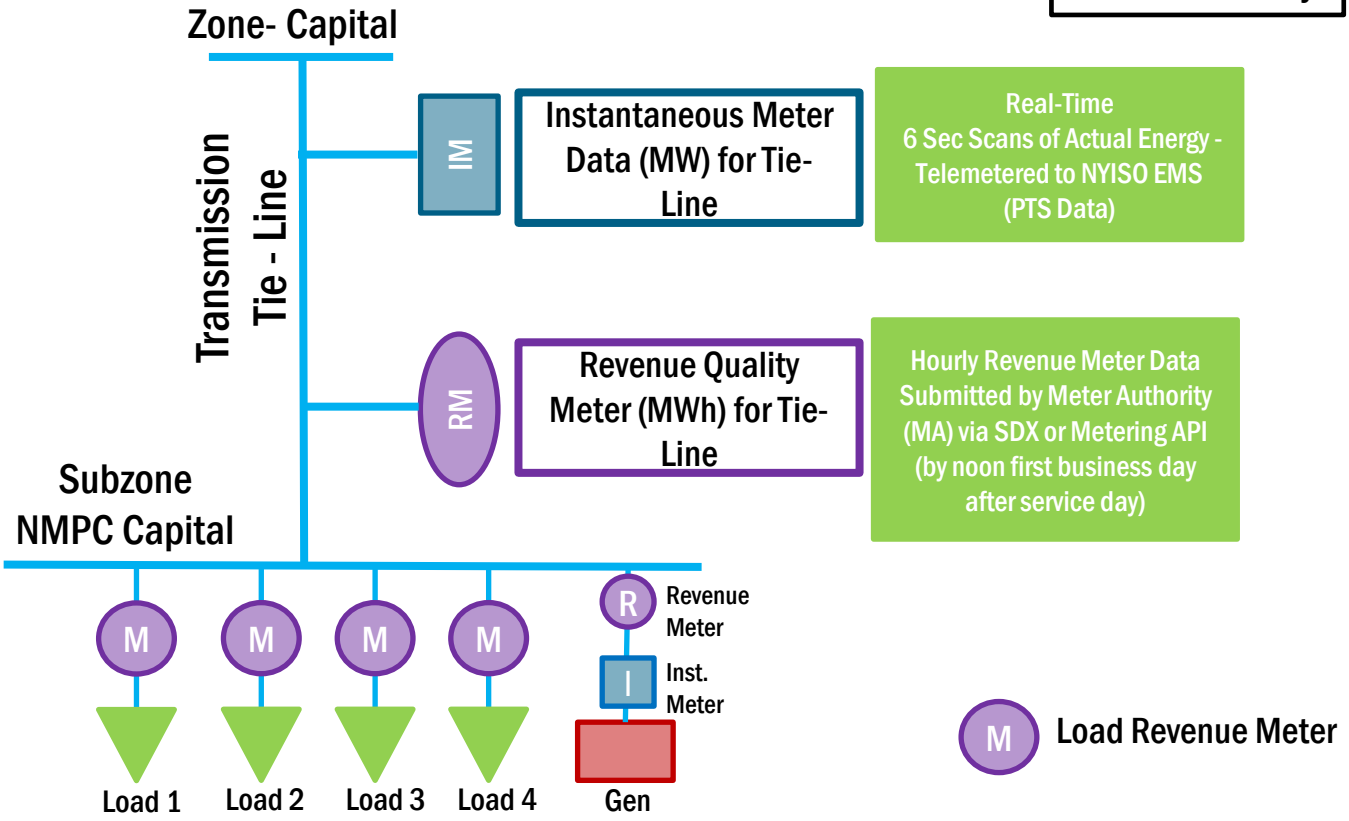
Estimating Sub-Zonal Load

Illustration Only



Estimating Sub-Zonal Load

Illustration Only



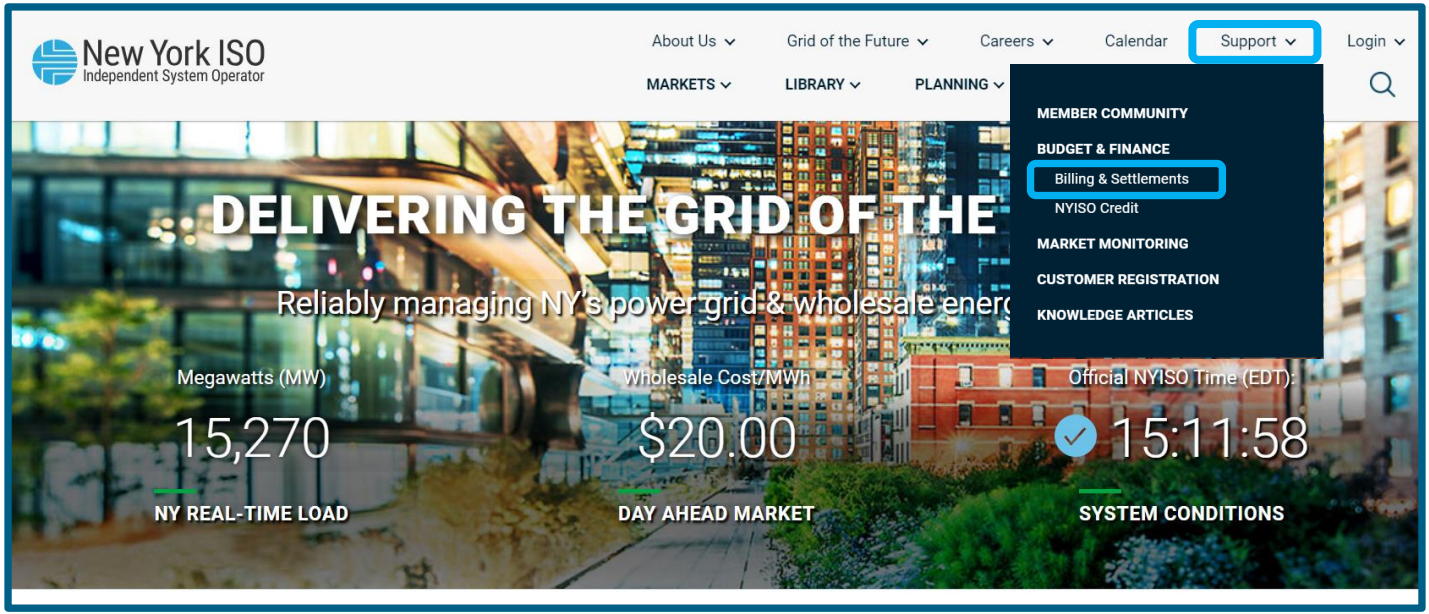
Estimating Sub-Zonal Load

- First determine electricity consumed in the sub-zone (withdrawals)
  - Use real-time metering data from:
    - Transmission Tie-Line(s)
    - Injections by Generator(s)
- Calculation performed for each RTD Interval

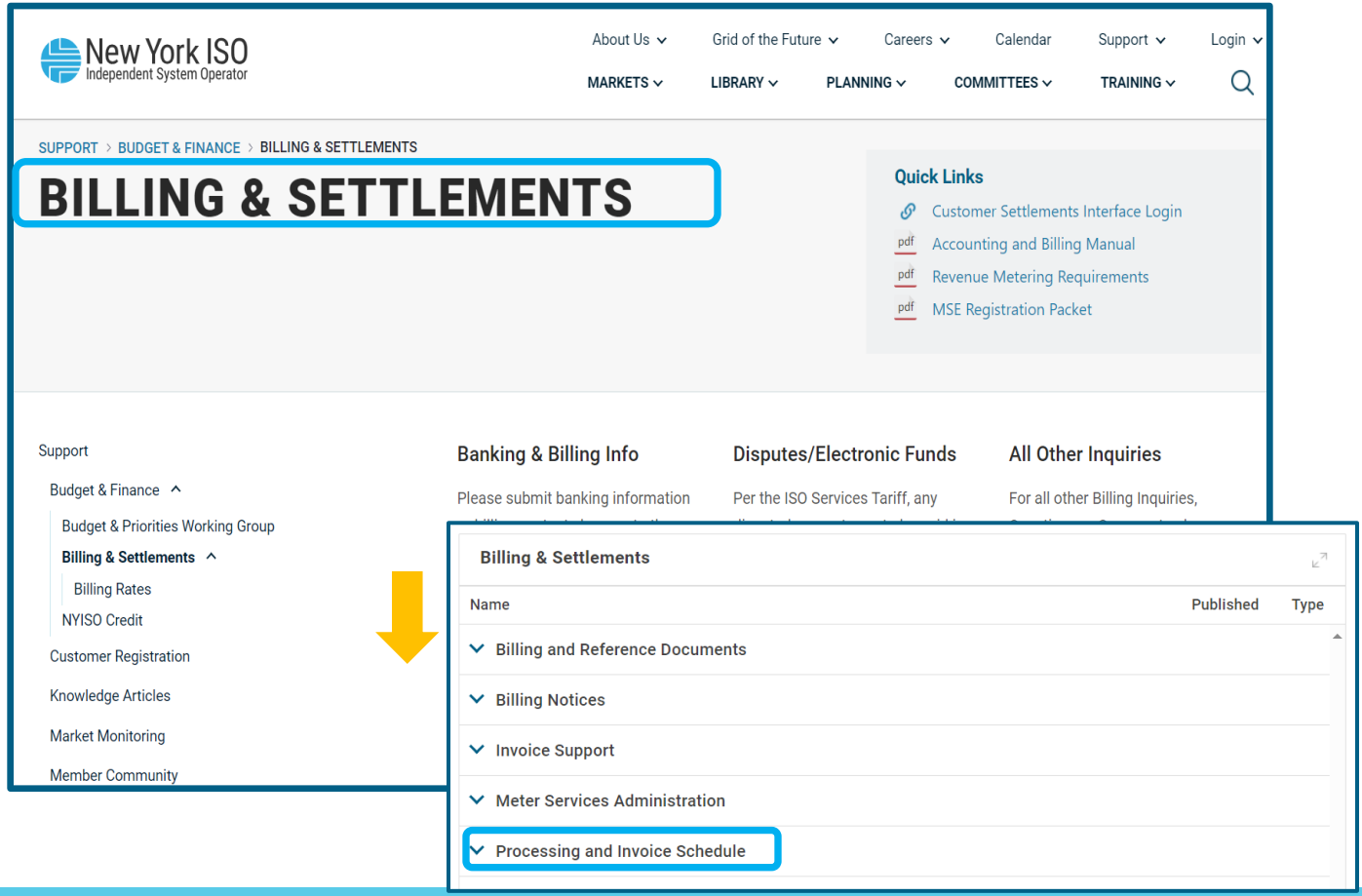
Sub-Zonal Load = Net Transmission Tie-Line Flows + Net Generation Injected − Sub-Zonal Transmission Losses

Meter Data Schedules

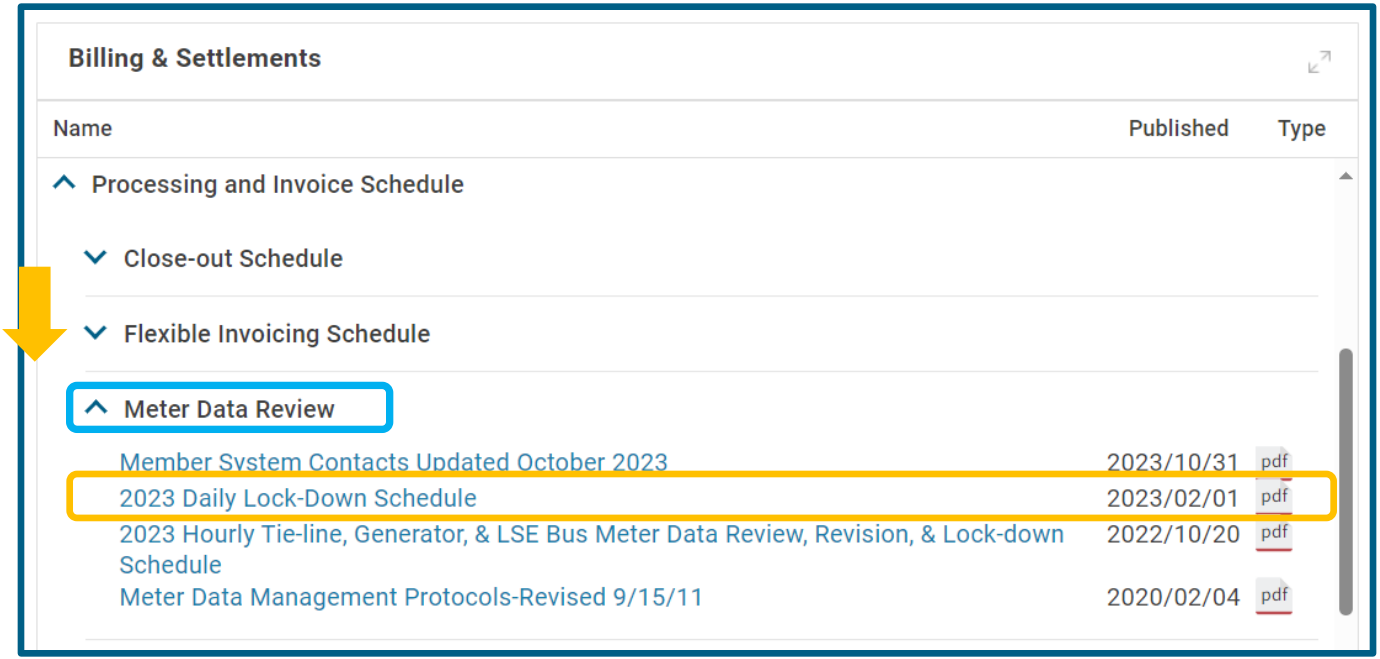
Locating Meter Data Schedules



Locating Meter Data Schedules



Daily Lock-Down Schedule



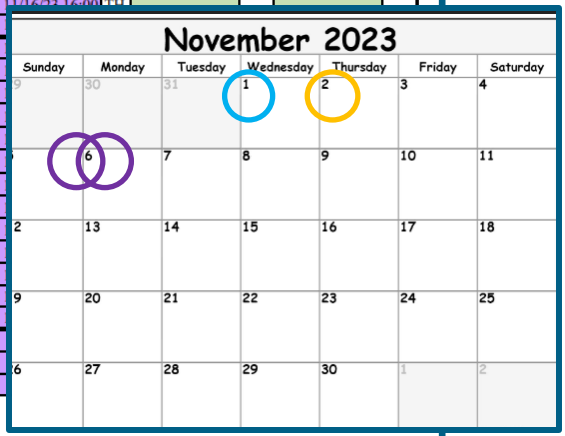
Daily Lock-Down Schedule

New York ISO
Independent System Operator

Daily Lock-down Schedule - Initial Month - November 2023

Billing Day		Lock-down for Daily Advisory		Unlock For Updates		Re-Lock After Updates	
11/1/2023	W	11/2/23 12:00	TH	11/6/23 8:00	M	11/6/23 16:00	M
11/2/2023	TH	11/3/23 12:00	F	11/6/23 8:00	M	11/6/23 16:00	M
11/3/2023	F	11/6/23 12:00	M	11/8/23 8:00	W	11/8/23 16:00	W
11/4/2023	S	11/6/23 12:00	M	11/8/23 8:00	W	11/8/23 16:00	W
11/5/2023	S	11/6/23 12:00	M	11/8/23 8:00	W	11/8/23 16:00	W
11/6/2023	M	11/7/23 12:00	T	11/9/23 8:00	TH	11/9/23 16:00	TH
11/7/2023	T	11/8/23 12:00	W	11/13/23 8:00	M	11/13/23 16:00	M
11/8/2023	W	11/9/23 12:00	TH	11/13/23 8:00	M	11/13/23 16:00	M
11/9/2023	TH	11/13/23 12:00	M	11/15/23 8:00	W	11/15/23 16:00	W
11/10/2023	F	11/13/23 12:00	M	11/15/23 8:00	W	11/15/23 16:00	W
11/11/2023	S	11/13/23 12:00	M	11/15/23 8:00	W	11/15/23 16:00	W
11/12/2023	S	11/13/23 12:00	M	11/15/23 8:00	W	11/15/23 16:00	W
11/13/2023	M	11/14/23 12:00	T	11/16/23 8:00	TH	11/16/23 16:00	TH
11/14/2023	T	11/15/23 12:00	W	11/17/23 8:00	F		
11/15/2023	W	11/16/23 12:00	TH	11/20/23 8:00	M		
11/16/2023	TH	11/17/23 12:00	F	11/20/23 8:00	M		
11/17/2023	F	11/20/23 12:00	M	11/22/23 8:00	W		
11/18/2023	S	11/20/23 12:00	M	11/22/23 8:00	W		
11/19/2023	S	11/20/23 12:00	M	11/22/23 8:00	W		
11/20/2023	M	11/21/23 12:00	T	11/27/23 8:00	M		
11/21/2023	T	11/22/23 12:00	W	11/27/23 8:00	M		
11/22/2023	W	11/27/23 12:00	M	11/29/23 8:00	W		
11/23/2023	TH	11/27/23 12:00	M	11/29/23 8:00	W		
11/24/2023	F	11/27/23 12:00	M	11/29/23 8:00	W		
11/25/2023	S	11/27/23 12:00	M	11/29/23 8:00	W		
11/26/2023	S	11/27/23 12:00	M	11/29/23 8:00	W		
11/27/2023	M	11/28/23 12:00	T	11/30/23 8:00	TH		
11/28/2023	T	11/29/23 12:00	W	12/1/23 8:00	F		
11/29/2023	W	11/30/23 12:00	TH	12/4/23 8:00	M		
11/30/2023	TH	12/1/23 12:00	F	12/4/23 8:00	M		

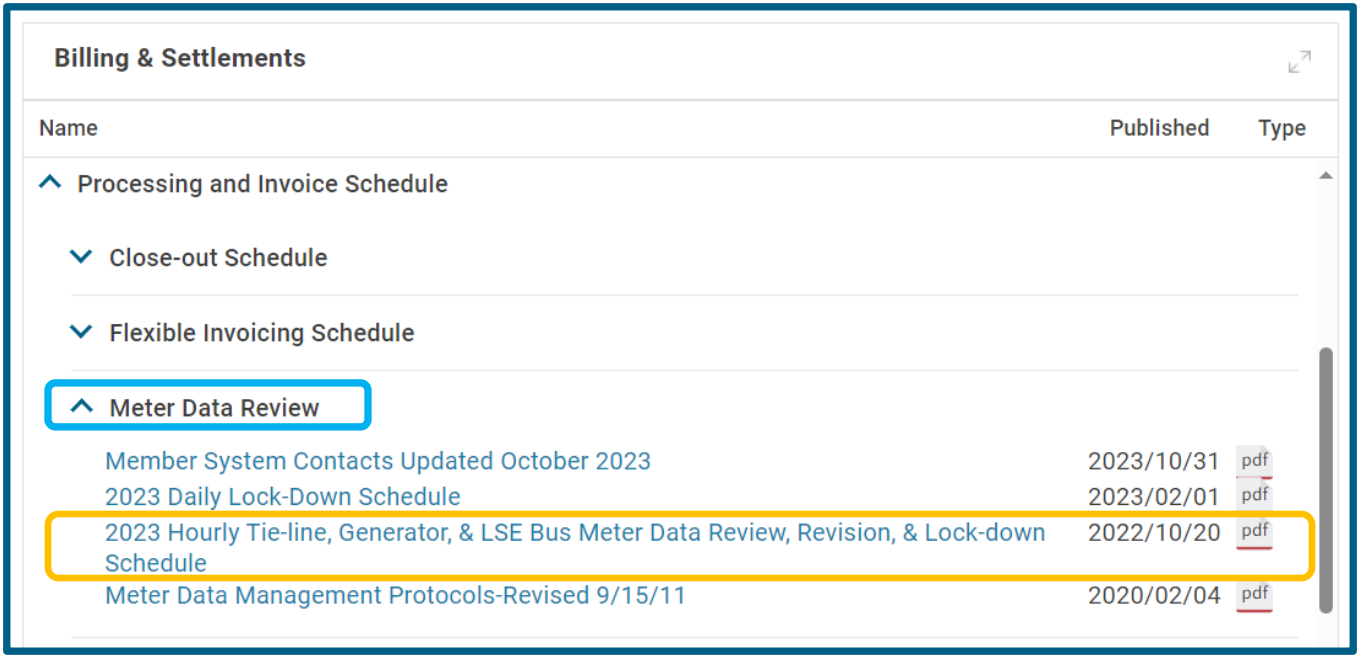
In-Month Open Season			
Unlock For Updates		Re-Lock After Updates	
11/20/23 8:00	M	11/20/23 16:00	M



**Billing Day 11/9 will have a delayed lock-down for MA's
**Billing Day 11/7 will have a delayed unlock for updates for MA's

** 11/23 and 11/24 are NYISO Holiday's

Review, Revision, and Lock-Down



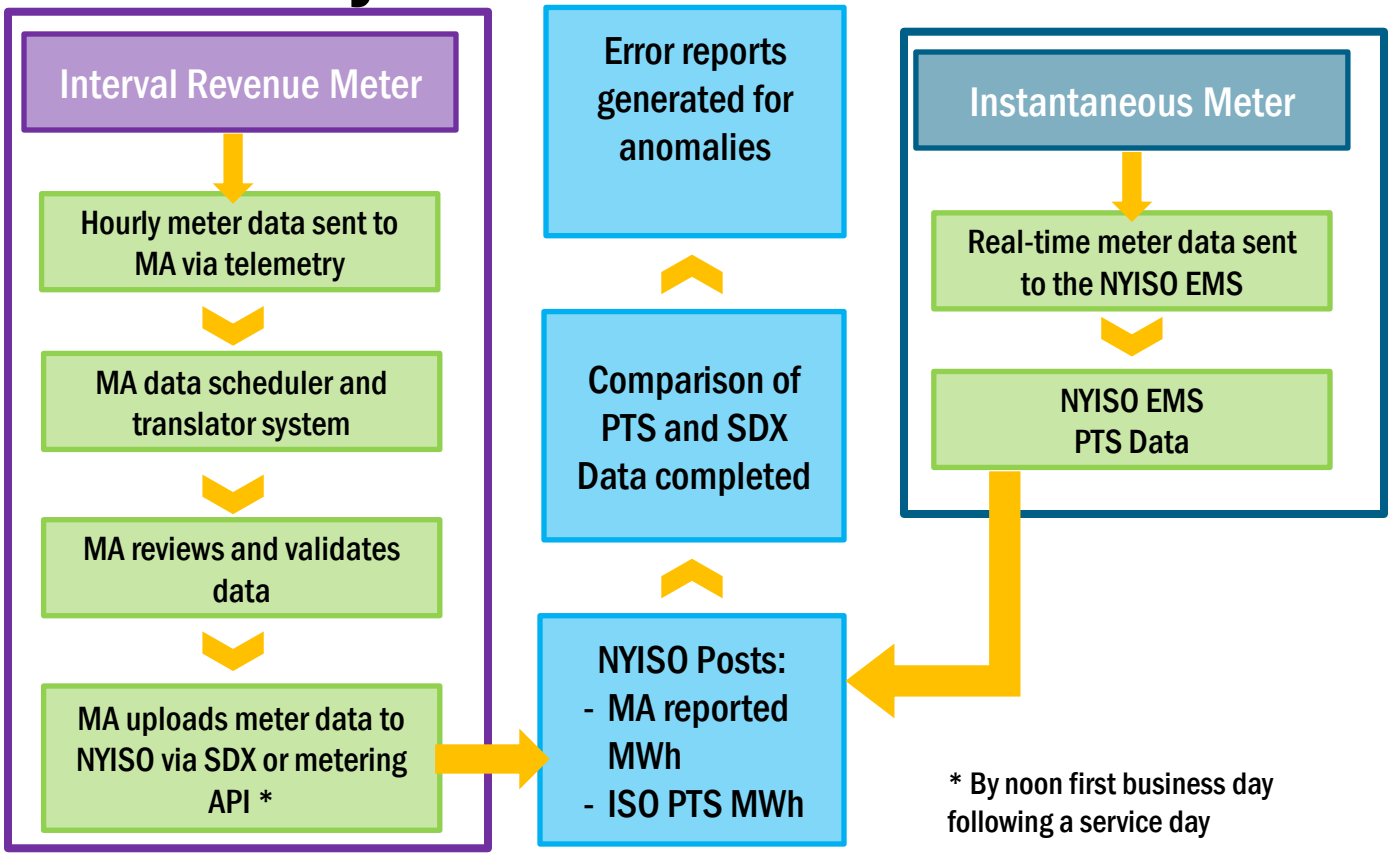
Review, Revision, and Lock-Down

New York ISO
Independent System Operator

Billing Month	November 2023
Initial Invoice Date	December 7, 2023
Period for Tie-line & Generator Metering Revision Submission by Meter Authorities Begins	December 13, 2023
Period to Challenge Tie-line & Generator Metering Only Through Written Request Begins	January 12, 2024
Period to Challenge Tie-line & Generator Metering Data Ends (Day-55)	January 31, 2024
Tie-line & Generator Metering Precluded From Further Revisions (Day-60)	February 5, 2024
LSE Bus Metering Data for 4-Month True-up Due From Meter Authorities (Day-70)	February 15, 2024
4-Month True-up LSE Metering Posted For Review (Day-75)	February 20, 2024
4-Month True-up LSE Metering Revisions Suspended for Invoice Prosessing	March 1, 2024
4-Month True-up Advisory LSE Metering Posted For LSE Review & Challenge** (Day-90)	March 6, 2024
Period to Challenge LSE Bus Metering Data for 4-Month True-up Ends (Day-100)	March 18, 2024
LSE Bus Metering Data for 4-Month True-up Precluded from Further Revisons (Day-105)	March 21, 2024
4-Month True-up LSE Metering Revisions Suspended Due to Invoicing (Day-120)	April 5, 2024
Close-out Settlement LSE Metering Due From Meter Authorities (Day-130)	April 15, 2024
Close-out Settlement Results and LSE Metering Posted For Review & Challenge** (Day-135)	April 22, 2024
Period to Challenge LSE Metering Ends (Day-145)	April 30, 2024
Close-out Settlement LSE Metering Data Finalized (Day-150)	May 6, 2024

* Any deadline that falls on a Saturday, Sunday or holiday for which the NYISO is closed is observed on the NYISO's next business day.

Meter Data and Settlements- Summary



* By noon first business day following a service day

Metering Fundamentals

- Reference Material
  - NYISO Revenue Metering Requirements Manual
    - Meter Authorities Roles – Section 4.3
    - Metering Terminology – Section 1.2
    - Metering System Equipment – Section 2.2
    - Meters for Settlement – Section 4.1 and 4.4
  - NYISO Control Center Requirements Manual
    - Metering Terminology – Section 1.1
    - Metering System Equipment – Section 3.1
  - NYISO Accounting and Billing Manual
    - Meters for Settlement – Section 3.2.1 and 4.1.3
    - Estimating Sub-Zonal Load – Section 3.2.2
    - Meter Data Schedules – Section 3.2
  - NYISO Billing and Settlement Services – Lockdown Schedules
    - 2018 Daily Lock-Down Schedules
    - 2018 Hourly Tie-Line, Generator, and LSE Bus Meter Data, Review, Revision, & Lock-Down Schedule