Exploration of Domestic High-end Electricity Meters for Power Grid Gateway Metering and Export Expansion

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Abstract

This text primarily introduces the differences in performance and functional design between imported 0.2S-class grid gateway electricity meters and commercial/industrial user meters, and how these differences influence the development of domestic high-end electricity meters. The article mentions the excellent performance and functions of these imported meters, such as high-precision measurement, wide-range overload capability, voltage circuit operational design, etc. These imported meters represent the highest technical level of international electricity meter design and therefore possess significant application value. The article also discusses how to enable domestic 0.2S-class multifunctional meters to fully assume the position of primary meters for grid gateway metering and to export to the international high-end meter market. This requires comprehensive research on the differentiated design of imported 0.2S-class grid gateway electricity meters, evaluation of their technical standards and the practicality of current reference standards, and discussion and formulation of enterprise standards for new domestic multifunctional meters. The article also provides detailed technical specifications regarding accuracy, current range overload capability, voltage circuit operational design, time-of-use tariffs, and other aspects of 0.2S-class imported gateway meters. These technical details help deepen understanding of the advantages and characteristics of imported meters, providing reference and guidance for the development of domestic meters. This paper's discussion on the performance and functional design of imported 0.2S-class grid gateway electricity meters and commercial/industrial meters helps promote the development of domestic high-end meters and enhance their competitiveness in the international market. Meanwhile, it also provides valuable reference for the application requirements of the global meter market and the development of new metering technologies.

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Full Text

Exploration of Domestic High-End Meters Entering Grid Gateway Metering and Expanding Exports

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Abstract

This paper examines the performance and functional design differences between imported 0.2S class grid gateway energy meters and industrial-commercial customer meters, analyzing how these differences influence the development of domestic high-end meters. The imported meters represent the highest international technical standards, offering exceptional performance including high-precision metering, wide overload current ranges, and sophisticated voltage circuit operation designs. To enable domestic 0.2S class multifunctional meters to assume primary gateway metering roles and penetrate international high-end markets, comprehensive research on the differentiated designs of imported meters is essential. This research provides the foundation for evaluating international technical standards, assessing the practicality of current reference standards, and formulating new enterprise standards for domestic multifunctional meters. The paper details technical specifications including accuracy, current range overload capability, voltage circuit design, and time-of-use (TOU) rates for imported 0.2S class gateway meters. These technical insights illuminate the advantages of imported meters and serve as valuable references for improving domestic meter design, enhancing competitiveness in global markets, and addressing evolving metering technology requirements worldwide.

Keywords: High-end meters; Grid gateway metering; CLC number: TM933.4

Introduction

This study focuses on imported high-end electricity meters, particularly 0.2S class grid gateway meters that represent the pinnacle of international energy meter design. Some emerging meter technologies also involve imported 0.2S class industrial-commercial meters. Currently, two key objectives drive the industry: establishing domestic 0.2S class multifunctional meters as primary gateway metering devices and expanding into international high-end markets. Achieving these goals requires comprehensive investigation of the differentiated designs in imported 0.2S class gateway meters to evaluate international technical levels, assess the practicality of existing reference standards, and develop enterprise standards for new domestic multifunctional meters.

Differentiated design analysis examines several critical aspects: which imported gateway meter specifications exceed IEC standards or offer functions not covered by IEC; what performance and functional variations exist among comparable imported meters to identify peak values for each metric; what technical differences and gaps exist compared to domestic 0.2S class multifunctional meters; and how to adapt to global market demands and emerging metering technologies. This paper synthesizes and distills the performance and functional designs of imported 0.2S class gateway and industrial-commercial meters, presenting differentiated features and specifications to guide domestic high-end meter quality improvement and design enhancement.

The technical content is compiled from specifications of nine imported high-end meter models: six 0.2S class grid gateway meters (Landis+Gyr ZQ202/E850 series, Schlumberger/ITRON Q1000, Canada ION8600, Landis+Gyr MAXsys2510, Europe ISKRA WU.TE432, and USA AMETEK JEMSTAR) and three 0.2S class industrial-commercial meters (GE kV2c, EDMI, and Enermet E700). Specific error test data under particular operating conditions are extracted from the Chongqing Electric Power Research Institute's *Performance Evaluation Report for Gateway and Large-User Energy Meters*.

Technical Performance and Functional Design of Imported 0.2S Class Meters

1. Accuracy of 0.2S Class Imported Gateway Meters

1.1 Full-Power, Four-Quadrant Energy Metering **a. High-precision forward and reverse active energy metering** Under conditions of 0.05%In to Imax with cosΨ=1, the meter load curve remains flat with factory error <0.05% (ZQ202). Under 0.05%In to Imax with cosΨ=0.5, the load curve stays flat with factory error <0.08% (ZQ202). At phase angles of 90°$±0.5°, 270°±$0.5° with In, meter error is controlled to <1% (Chongqing Electric Power Research Institute).

b. Four-quadrant reactive energy metering: $±$0.2% (Q1000)

c. Four-quadrant apparent energy metering: $±$0.3% (Q1000). Apparent energy uses two algorithms: vector method and arithmetic method.

1.2 Low Power Factor Metering (Q1000) Qh metering accuracy: $±$0.3%

1.3 Separate Fundamental and Harmonic Energy Metering (ION8600)

1.4 Distortion Power Factor Metering (kV2c) Distortion Power Factor (DPF) is the ratio of distortion power (D) to apparent power (S). The meter's active power factor (PF), reactive power factor (RF), and distortion power factor (DPF) are all vectors with the composite formula: $\sqrt{(PF^2 + RF^2 + DPF^2)} = 1$. The composite formula for active power (P), reactive power (Q), distortion power (D), and apparent power (S) is: $S^2 = P^2 + Q^2 + D^2$. Calculation basis: power protection system (omitted).

1.5 Applicable International Standards (Q1000)

- ANSI C12.1: U.S. national standard for electricity meter metering specifications
- ANSI C12.20: U.S. national standard for electricity meters (Class 0.2 and 0.5)
- ANSI/UL 50: U.S. national standard/safety (pending inquiry)
- ASMT B117: U.S. materials testing standard for salt spray test machine operation procedures
- ASMT D999: U.S. materials testing standard for container vibration testing methods
- IEC60807/IEC62053-22: Static active energy meters (Class 0.2S and 0.5S)
- IEC61268/IEC62053-23: Static reactive energy meters (Class 2 and 3)
- IEC60068-2-6: Environmental testing—Vibration (sinusoidal)
- IEC60068-2-27: Environmental testing—Shock

1.6 Effective Service Life Guaranteed high precision and stability for over 15 years (ZQ202).

2. Wide Current Range Overload Capability (ZQ202)

- Rated current/maximum current: In (5A)/Imam (120%)
- Meter measurement technology achieves: 170%In
- Meter thermal parameters achieve: 12A (minimum 1.5×Imax)

3. Voltage Circuit Operation Design

a. Input voltage: 55–530V automatic adjustment (JEMSTAR)

b. Voltage loss and recovery timing design (ZQ202) - Voltage loss (power-down) control sequence: Input/output lockout: immediate; Contact output: 100ms; Switch to backup operation: 0.5s; Data storage: additional 0.2s; Cutoff: approximately 2.5s. - **Voltage recovery (power-up) 3-phase control sequence:** Function ready: after 1–3s; Energy direction and phase voltage determination: after 1–3s.

c. Flexible wiring configuration: The same EDMI meter can be used for both three-phase three-wire and three-phase four-wire applications, with software-configurable wiring modes based on field requirements (EDMI).

4. Time-of-Use (TOU) Rates (Q1000)

Features include current (active) TOU rate tables, backup TOU rate tables, 7 daily billing formats, 7 TOU rates plus total rate, up to 400 daily rate patterns, up to 665 rate period switching points, 16 rate event status trigger signals, up to 12 seasons annually, perpetual calendar, multiple holidays, support for simultaneous (overlapping) rates, and support for temporary rates to replace current rates.

5. Harmonic Measurement (ION8600)

ION8600 offers harmonic analysis capability: Type B monitors 2nd–63rd harmonics; Type A monitors 2nd–127th harmonics (with host computer software support), parsing all voltage and current inputs including neutral current. Measurement accuracy is 1% (Types A and B up to 63rd harmonic). Single parsing extends to 40th order including amplitude, phase angle, and interharmonics (Type A). Features include total even harmonic distortion rate, total odd harmonic distortion rate, total harmonics (even + odd), harmonic energy metering, K-factor (5% measurement accuracy), and crest factor (1.0% full-scale measurement accuracy).

6. Typical Meter Constants (ZQ202)

For Un=3$\times100/\sqrt{}3V or 3\times$100V, In=5A, the meter constant is 20000 imp/kWh.

7. Starting Power (ZQ202)

- Starting active power: <0.05% of rated active power
- Starting reactive power: <0.1% of rated reactive power

8. Time Base

a. Typical Real-Time Clock (RTC) - Clock accuracy (23°C): <5 ppm (ZQ202) - 20MHz crystal oscillator (WU.TE432): RTC controlled by crystal oscillator complies with IEC61038 standard, backed up by supercapacitor or lithium battery plus supercapacitor. Supercapacitor provides 250h backup; lithium battery provides 3-year backup during main power loss.

b. RTC Synchronization Sources (ION8600) - Internal crystal oscillator - Measured system/network line frequency ($\pm$10 PPM), default setting - External ASCII receiver, accuracy $\pm$1ms, with dedicated communication interface for GPS synchronization signal input - Optional IRIG-B GPS receiver: accuracy $\pm$1ms - Supports master metering system or data acquisition terminal time synchronization

9. Demand Calculation (Q1000)

a. Demand calculation types: Maximum demand, minimum demand, current demand, previous demand, target demand, cumulative demand, continuous cumulative demand, optional related demand.

b. Demand registers: Block and sliding window demand with programmable demand period and sub-interval; thermal demand calculation; demand period synchronized with meter internal clock.

10. Voltage Hour (Vh), Current Hour (Ih), Cycle Hour (Hzh), Power Factor Hour (PFh) Metering (Q1000)

11. Meter Security (ION8600)

Beyond traditional anti-tampering features, ION8600 provides advanced security measures to automatically detect, record, and report: PT/CT phase loss; PT/CT reverse phase or installation errors; peak demand register resets; power-on/power-off events.

12. Accurate Instantaneous Measurement and High-Speed Recording

a. High measurement accuracy (ION8600): Voltage: 0.1%; phase current: 0.1%; neutral current: 0.4%; frequency (47–63Hz): $±$0.01Hz; kW, kVAr, kVA: 0.2% (reference error); power factor: 0.5% (reference error).

b. Real-time measurement (ION8600): Provides high-precision real-time measurement (second-level resolution) and high-speed (1/2 cycle) measurement including phase voltage, line voltage, load current, neutral/ground current, active power, reactive power, apparent power, power factor, frequency, voltage/current unbalance, and phase sequence.

c. High-speed recording (ION8600): Records disturbance and voltage loss details with minimum intervals of 1/2 cycle (10ms), triggered by limit violations or external devices, with automatic reserved storage for emergency events.

d. Fault waveform recording (ION8600 Type A): Simultaneously captures waveforms on all voltage and current channels to analyze interference sources. Recording technology includes sub-cycle disturbance capture, maximum 96-cycle fault waveform recording, sampling rates up to 256 points/cycle, and dynamic ranges: 14-bit AD for voltage circuits, 18-bit AD for current circuits.

e. Apparent power calculation and analysis (E700): Vector algorithm uses Vector VA = $\sqrt{}$(active power^2 + reactive power^2); arithmetic algorithm uses Arithmetic VA = Vrms $\times$ Irms. Vector VA excludes harmonic effects while arithmetic VA includes them.

13. Power Quality Measurement and Control

a. Power quality monitoring (MAXsys2510): With widespread use of high-precision equipment, power quality monitoring is becoming a key differentiator. MAXsys2510 features include: voltage sag/swell recording; instantaneous current change capture; total harmonic distortion measurement; abnormal loss event recording; half-cycle resolution; storage for up to 254 power quality events; alarm calls when power quality degrades; online fault diagnosis; and precise second-level timestamping.

b. Power quality monitoring and analysis (ION8600 Type A): - **Standards compliance:** Harmonics and interharmonics per IEC61000-4-7; flicker per IEC61000-4-15; voltage tolerance curves per CBEMA/ITIC; public power supply voltage characteristics (including disturbance indicators) per EN50160; harmonic control recommendations per IEEE519; power quality monitoring practices per IEEE1159. - **Sub-cycle disturbance capture:** See Section 12d. - **Power supply reliability detection:** ION8600 displays reliability using "nines" notation for intuitive reliability assessment. - **Limit violation detection:** Records and reports voltage/current unbalance details including voltage/voltage loss, frequency/power factor changes, and voltage deviation. - **Harmonics and harmonic energy metering:** See Section 5. - **Voltage surge/sag detection:** Captures voltage surges/sags, analyzes severity and potential hazards, plots voltage tolerance curves, calculates excess/deficient energy during events, triggers per-phase waveform recording (ION8600 Type A) or control outputs, and enables software analysis. - **Transient capture:** ION8600 Type A records sub-cycle transients as short as 65 microseconds (60Hz) or 78 microseconds (50Hz). - **Sequence component measurement:** Measures zero, negative, and positive sequence components for all voltages and currents, calculating inter-phase unbalance.

14. Electromagnetic Interference Resistance (ION8600)

- Electrostatic discharge test (B): IEC1000-4-2
- Radiated interference immunity test (A): IEC1000-4-3
- Electrical fast transient test (B): IEC1000-4-4
- Surge immunity test (B): IEC1000-4-5
- Operational interference test: IEC1000-4-6
- Surge interference immunity test: ANSI C62.41
- IEEE protective relay and relay system surge withstand capability (SWC) test: IEEE C.37-90.1-1989
- U.S. national standard for electricity meters (Class 0.2 and 0.5 accuracy): ANSI C12.20-1998

15. Grid Loss Measurement, Compensation, and CT/PT Dynamic Correction

a. Transformer and power line loss measurement and compensation: - **Calculation (Q1000):** Voltage-squared hour (V^2h) recording and current-squared hour (I^2h) recording. - **Compensation methods (ION8600):** Flexible compensation with simple setup, per-second refresh, applicable to all supported communication protocols. - **Measurement and calculation (MAXsys2510):** MAXsys2510 is a leader in transformer and line loss measurement, with standard hardware capable of calculating losses for three series-connected transformers or three series transmission lines. The meter supports up to six parameter sets for different loss calculations, enabling adjustments when transmission lines are reconfigured. Using peer-to-peer communication, it can add or subtract partial loads before calculating losses—critical when metering CTs are located between the power transformer and loads.

b. CT/PT dynamic correction (MAXsys2510): MAXsys2510 is the only power meter capable of dynamically correcting CT/PT distortion within its operating range, eliminating high replacement costs.

c. Real-time CT/PT angle error and ratio error correction (EDMI): Based on voltage and current transformer errors at different load points, interpolation algorithms create continuous error curves for real-time compensation, reducing CT/PT error impact on energy measurement to near zero.

16. Load Profile Recording and Event Logging

a. Non-volatile memory capacity (ION8600 Type A): 10 MB

b. Load profile recording: ION8600 (Type A) supports 50 data logs with 16 parameters each (800 total parameters). Q1000 supports up to 10 sets of load profile recording with 24 channels per set, each with independent time intervals.

c. Event logging (ION8600): Provides event, sequence-of-events, and alarm logging with 1ms timestamp resolution, recording power quality event details including amplitude, duration, and equipment status. GPS-equipped ION meters enable system-wide event diagnosis and equipment status monitoring.

17. Multi-Communication Interfaces and Protocols

a. ION8600 communication: - **Serial ports:** One RS232/RS485 and one RS485 port (order-specified) with protocols ION, DNP3.0, ModbusRTU, GPS; rates: RS232 (300–115200bps), RS485 (300–57600bps); opto-isolated. - **Infrared port:** ANSI C12.13 Type2 with protocols ION, ModbusRTU, DNP3.0; rates: 300–19200bps; half-duplex. - **Ethernet:** Optional 10Base-T via Ether Gate for direct LAN/WAN access, enabling data transfer between Ethernet and up to 31 serial devices; protocols: TCP/IP, ION, ModbusTCP; rate: 10Mbps. - **Built-in modem:** Optional dial-up modem with Modem Gate gateway (RJ11 or RJ31); protocols: ION, DNP3.0, ModbusRTU; rates: 300–33600bps with auto-rate detection; half-duplex. - **IRIG-B interface:** Optional IRIG-B input for clock synchronization; accuracy: 1ms; rated voltage: 5V DC ($±$10%), maximum: 8V DC.

b. ZQ202 communication: - Optical interface for automatic meter reading (IEC62056-21): Protocol dlms (IEC62056-42/46/53/61/62); rate: 9600bps; serial, half-duplex, asynchronous with start/stop bits. - **RS485 interface (daisy chain, ISO8482 standard):** Protocol dlms (IEC62056-42/46/53/61/62); maximum distance/rate/meter count: 1200m/19.2kbps/16 meters, 550m /38.4kbps/32 meters, 250m /57.6kbps/32 meters; serial, full-duplex, two-wire connection with polarity.

c. Q1000 communication: High-speed options include frame relay, fiber optic, wireless, wired, telephone network, Ethernet, and microwave networks. Protocols: DNP3.0, IEC60807-5-102, IEC60807-5-102plus, miniDLMS, Modbus.

18. Output Pulse Specifications

Specification 1: Pulse width 40ms, maximum pulse frequency 12 Hz (ZQ202). **Specification 2:** Programmable pulse output (MAXsys2510) with four programmable interfaces supporting pulse output, upper/lower limit control, alarm and emergency calling, and communication control.

19. Display Modes

Data, curves, events, vector diagrams, harmonic bar charts; backlight: LED, 0–120 min.

20. Self-Diagnostic Technology

a. Self-diagnostics (ION8600): Continuous hardware, software, and data monitoring during power-up and operation, logging anomalies, enabling communication upload, emergency alarms, and immediate fault code display.

b. Self-diagnostics and alarms (EDMI): External status detection includes unbalanced power, voltage tolerance, PT faults, incorrect phase sequence, and reverse power with programmable thresholds and trigger times. Internal detection includes checksum data loss, clock faults, user-defined faults, modem faults, RAM/LCD faults, programming/data flash register faults, pulse output overflow, and battery faults, with LCD fault indicators.

21. Hardware Circuits

a. Proprietary metering chips: - Landis+Gyr ZQ202: Uses digital multiplier chip with AC sampling power algorithm—an international mainstream metering chip with proprietary core technology. - **ISKRA WU.TE432:** Based on proprietary TDM (time-division multiplier) technology with three-element measurement system for reactive energy via simulated wiring. Analog and digital circuits integrated on a single shielded chip ensure excellent metering, long-term stability, high reliability, and zero periodic calibration required during 30-year service life.

b. Active conversion technology with 14-bit ADC (Q1000): Achieves measurement accuracy approaching standard meter levels. This active conversion likely employs active zero-flux current transformer design for flat error curves in low-current ranges.

c. Supercapacitor: Power-off retention >20 days (QZ202).

d. Lithium battery: 10-year life (QZ202).

e. Data security: All metering data stored in two separate locations in non-volatile EEPROM as original and copy (WU.TE432).

22. Supporting Software (Q1000)

Compatible with ITRON MV-90; PC-PRO 98 programming software; Protocol Editor; HHF meter data file generation from PC-PRO 98 version 5.0 and above; Energy Audit; DC Systems SCADA compatibility for real-time applications.

23. Power Consumption (ZQ202)

a. Current circuit: <0.1VA
b. Voltage circuit: - Connected to PT circuit: Without contact/communication modules: 0.9VA (0.5W); With modules: 1.4VA (0.8W) - **Not connected to PT circuit:** PT circuit: 0.05VA; Auxiliary power typical: 0.1VA; Without modules: 3VA; With modules: 4.5VA

24. Meter Casing

a. Materials: Anti-static glass fiber reinforced plastic (ZQ202); flame-retardant polycarbonate reusable after meter life cycle (WU.TE432); fire-resistant self-extinguishing: IEC 60695-5-11 (960°C), UL94 (94VO) (WU.TE432).

b. Form factors (Q1000): Socket type; rack type; panel mount type; DIN standard type; Type A base type.

c. Protection: IEC60529 IP51 (ZQ202); double insulation with IP53 dust/water/flame protection compliance (WU.TE432).

The above summarizes 24 differentiated performance and functional design items for nine imported high-end meter models.

Commentary and Analysis

1. Current State of International Electronic Meter Technology and Leading Brands

a. Primary focus on high-precision active energy metering: Imported 0.2S class gateway meters achieve factory active metering error <$±0.05±0.5°, 270°±0.5° *withIn, activemeteringerrorremains* <±1×$ conventional multifunctional meters; temperature impact on accuracy is 5× lower than IEC standards; pulse output resolution is 10× higher than conventional meters; and its comprehensive metering performance essentially meets 0.1S class gateway meter design standards. Landis+Gyr is reportedly developing 0.1S class E860 series higher-precision settlement gateway meters while IEC is drafting 0.1S class static active energy meter standards.

b. Full-power metering accuracy exceeding IEC requirements: Active metering error <$±0.1±0.2±0.3±$0.3%. Notably, IEC currently lacks standards for apparent and Qh metering errors. The Schlumberger/ITRON Q1000 demonstrates deep research in full-power metering, employing active conversion technology (active zero-flux current transformer) for ultra-low loads.

c. Emerging fundamental active energy metering for power trade settlement: The ION8600 pioneered fundamental and harmonic active energy metering design internationally. Canada mandated fundamental active power metering for all meters installed from 2021. IEEE 1459 standard provides reasonable calculation methods, and many jurisdictions legally prohibit harmonic energy trading, requiring meters to reflect legal requirements.

d. Power quality monitoring as a key differentiation point: Imported high-end meters offer 9 categories with 35 monitoring items including standards compliance (flicker, etc., 5 items), fault waveform recording (1 item), reliability detection (1 item), limit violations (7 items), harmonic metering (11 items), voltage surge/sag detection (4 items), transient capture (1 item), sequence component measurement (4 items), and online fault diagnosis (1 item). Leading models include ION8600 and MAXsys2510.

e. Advanced measurement, recording, and communication technologies: ION8600 provides accurate instantaneous measurement, high-speed recording, and waveform capture with multiple communication methods and protocols.

f. Practical transformer and line loss measurement: MAXsys2510 leads in this area.

2. Why High-Priced Imported 0.2S Class Gateway Meters Are Selected for Primary Gateway Metering

Grid gateway metering represents the most critical measurement points in power systems. Per DL/T448 *Technical Management Regulations* *for Electric Energy Metering Devices*, primary and backup gateway meters are required. A 1 million kW generating unit or 1000kV UHV line carrying $ $1200A transmits >6 billion kWh annually. A mere 0.05% metering error creates annual settlement fluctuations exceeding $±1*millionRMB.Despiteimported*0.2*Sclassgatewaymeterscosting*8–10×$ more than domestic equivalents (40,000–50,000 RMB/unit) , grid authorities select international brands (ZQ202, Q1000, ION8600, MAXsys2510) as primary gateway meters to ensure long-term reliability and stability.

3. Assessment of Domestic High-End Meter Quality

Over the past decade, domestic smart meters have remained at medium quality levels due to low pricing, considering metering function design, reliability design, standards adoption, component selection, production process control, and type testing. Compared to imported 0.2S class meters, gaps include: - No reported use of dedicated digital multiplier metering chips; error control and load error curve compensation rely primarily on algorithm software. - Non-flat active metering and power factor error curves with large ultra-low-load errors; at phase angles near 90°, only Wasion meters use software error control while others show large errors (3–8%). - No full-power design schemes; fixed power metering items without options; fundamental/harmonic active metering development initiated by State Grid in 2019 remains unclear; IEEE 1459 not yet adopted. - Limited development of fast measurement and high-speed recording with only sporadic applications. - Missing power quality monitoring items; inconsistent views on its importance for differentiation. - Inadequate comprehensive research on reliability and stability; domestic reliability design, testing validation, component database construction, and enterprise reliability standard systems remain underdeveloped.

4. Path Forward for Domestic High-End Meters in Gateway Metering and Export Markets

Around 2000, Conlog and Wasion first launched 0.2S class three-phase multifunctional meters as backup gateway meters, initiating the process toward primary meter status.

a. 2006–2009 collaboration: The authors partnered with Wasion, Zhengzhou Wante, and Chongqing Electric Power Research Institute to develop quality discrimination testing technology for imported/domestic electronic three-phase multifunctional meters. In 2008, Zhengzhou Wante launched China's first high-precision three-phase meter quality test device with German EMH 0.01 class K2006 standard meter and PTB test report. In 2009, Chongqing Electric Power Research Institute submitted the *Performance Evaluation Report for Grid Gateway and Large-User Energy Meters* to State Grid.

b. 2011 breakthrough: Wasion developed China's first 0.1S class high-accuracy settlement gateway meter using digital multiplier technology, gradually achieving primary gateway meter status. Features include: active metering error <$±0.04±$0.1% accuracy over 15-year lifecycle; international high-reliability components; composite New-Cotes high-order integration and high-precision dynamic angle error compensation for flat load and power factor error curves. Since launch, it has gained State Grid, Southern Grid, and Inner Mongolia Grid recognition, winning bids against imported products, and partnered with Siemens for overseas markets.

c. 2014–2016 "Imported High-End Meter Full Performance Research" project: Collaboration among authors, Wasion, Chongqing Electric Power Research Institute, Zhengzhou Wante, Eastron, Longi Ningguang, Chongqing Huali, Qingdao Neusoft, and *Global Metering* magazine. Two technical meetings (Changsha 2014, Yinchuan 2015) produced minutes and reports including Chongqing EPRI's *Gateway Meter Performance Testing* and *Smart Meter Reliability Technology Research*, Wasion's *Analysis of Imported Gateway Meters* and introduction to IEC61709/SN29500 reliability prediction standards, and Eastron's interpretation of State Grid component specifications. The meetings identified significant gaps between domestic GB/T17215.941/IEC62059-41 and international IEC61709/SN29500 reliability prediction standards, noting domestic effective lifecycle assessment research is absent. The project concluded in October 2016 due to resource constraints.

Since 2006, domestic 0.1S class meter development has marked progress toward primary gateway meter status. However, comprehensive adoption at major grid points (large generator units, inter-regional UHV/EHV tie lines) and export expansion require solving numerous technical challenges beyond individual enterprise capabilities. Continued gradual development is needed, with industry authorities and grid companies organizing collaborative R&D on high-precision digital multiplier chips, reliability testing, lifecycle validation, and high-reliability components. Long-term parallel operation with imported meters for data comparison and continuous improvement will enable domestic high-end meters to achieve primary gateway meter status and volume exports to international high-end markets.

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Note: Figure translations are in progress. See original paper for figures.