

Experiences using miniPEMS for 2 and 3-wheeler testing:

PEMS 2.0 – From Portable Measurement *to* Scalable BS VII RDE Deployment

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Why two-wheeler real-world measurement matters

- Laboratory cycles remain essential, but they cannot reproduce every traffic, road and rider condition.
- Two-wheelers dominate mobility in many Indian cities, so scalable measurement matters.
- Real-world data can support procedure development, emissions engineering and in-use verification.
- BS7 development increases the value of representative data outside the laboratory





Motorcycles create a difficult measurement environment

➤ The measurement system must fit the vehicle!

- Limited payload, mounting space and electrical power
- Greater sensitivity to added mass and aerodynamic drag
- High vibration and changing vehicle attitude
- Small, rapidly pulsing exhaust flow
- Short exhaust systems and restricted probe locations





3DATX parSYNC® Portable Emissions Measurement Systems



The parSYNC[®] FLEX iPEMS

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➤ Pollutants measured in 3 sensor cartridges:

- C-GasMOD – CO, CO₂, HC via NDIR & O₂ via electrogalvanic,
- N-GasMOD – NO & NO₂ via electrochemical,
- Particulates – PN and PM via scattering, ionization and opacity sensor inputs (with VPR but no cutoff)
- Option of SN-cart – NO and SO₂ via electrochemical

➤ Features:

- Small size – 33 L total – consists of two units (FLEX+CUBE), allowing flexible installation configuration.
 - FLEX: 40.2 x 15.3 x 29.4 cm, CUBE: 34.8 x 14.7 x 29.4 cm,
- Onboard computer - laptop not needed during test.
- Low weight – 12.7 kg (with 4 batteries), 9.8 kg (without batteries),
- Battery life: ~4 hours with max 4 batteries, hot-swappable during test,
- Easy to maintain and operate, simple & quick calibration process,
- Rugged design: suitable for high vibration and tough conditions.





parSYNC[®] FLEX-PNC iPEMS

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➤ Pollutants measured:

- The FLEX-PNC has the same suite of gas sensors as the FLEX (CO₂, CO, NO, NO₂, HC, O₂), but...
- FLEX-PNC incorporates an NMi, METAS, and PTB certified particle number concentration (PNC) sensor based on the extended diffusion charging principle.

➤ FLEX-PNC features:

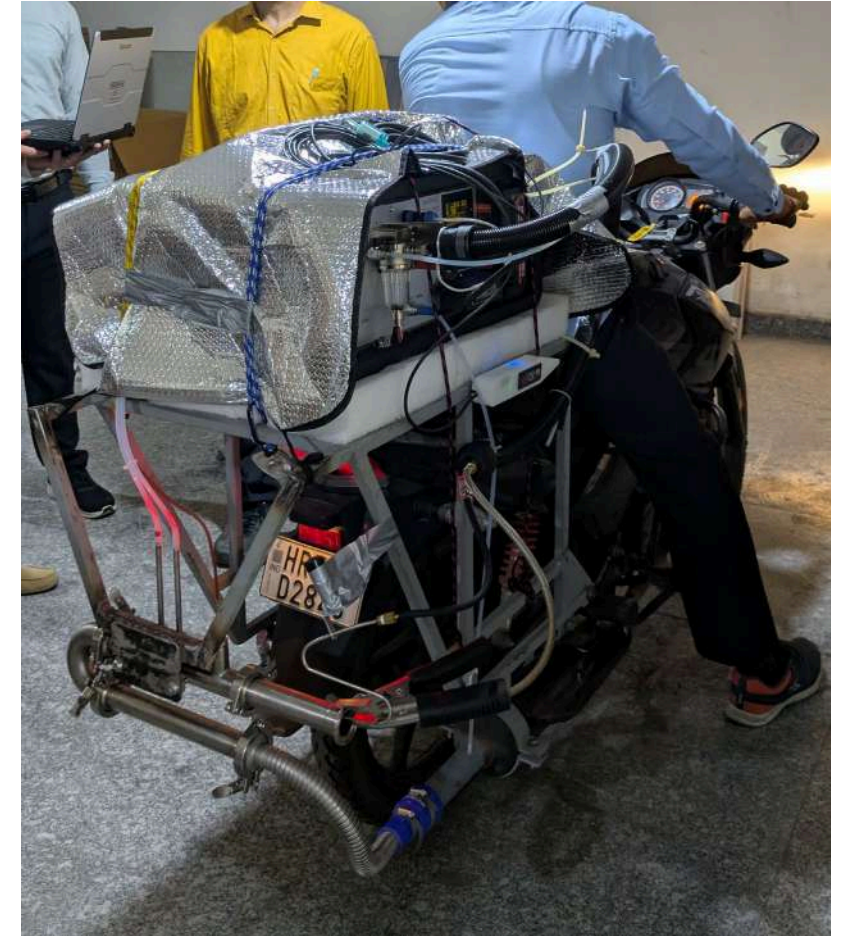
- Small size – 61 L total in one box – 40 x 55 x 24 cm,
- Onboard computer: laptop not needed during test
- Low weight: 19 kg (with batteries), 16.8 kg (without batteries),
- Battery life: ~1.5 hrs with two batteries, hot-swappable during test,
- Rugged design, easy to maintain and operate,
- PN 23 nm and 10 nm simultaneously,
- PM output is available.





Exhaust flow is central to mass emissions

- Concentration alone cannot provide g/km or #/km results.
- Small engines generate strongly pulsating exhaust flow.
- A dedicated motorcycle EFM reduces reliance on modelled flow from ECU variables.
- Stable, synchronised flow improves the credibility of transient mass calculations.





BS VII: Laboratory Reference. Real-World Scale.



REAL-WORLD MEASUREMENT

Representative traffic, road, rider and ambient influences



REFERENCE LABORATORY

Controlled cycles, reference instruments and repeatable comparisons

PEMS 2.0 extends laboratory-quality measurement beyond the laboratory and into scalable field deployment.





Examples

- The FLEX and FLEX-PNC have been proven for small engine mobile testing in other campaigns, including on-road motorcycle testing



110 cc Hero Passion Pro



600 cc Yamaha YZF R6S



1298 cc Yamaha FJR1300





➤ Complete on-vehicle measurement in Indian traffic

- 2023 Hero Passion Pro (110 cc spark-ignition engine)
- Road test in Delhi traffic on 7 August 2025
- FLEX-PNC measured gases, PM, PN10 and PN23
- A motorcycle exhaust flow meter enabled second-by-second mass emissions

Idle Test Results

Test	Time (hrs)	Distance (km)	NO2 (mg/h)	NO (mg/h)	NOx (mg/h)	CO2 (g/h)	CO (mg/h)	HC (mg/h)	PM (mg/h)	PN23 (#/h)	PN10 (#/h)
Idle 1	0.039	0.00	-9.3	299.0	289.8	1007.030	40,1	3186.7	490.6	2.80E+13	2.83E+13
Idle 2	0.056	0.19	0.0	186.9	186.9	862.268	675	159.7	0.612	4.43E+10	4.57E+10

Drive Test Results

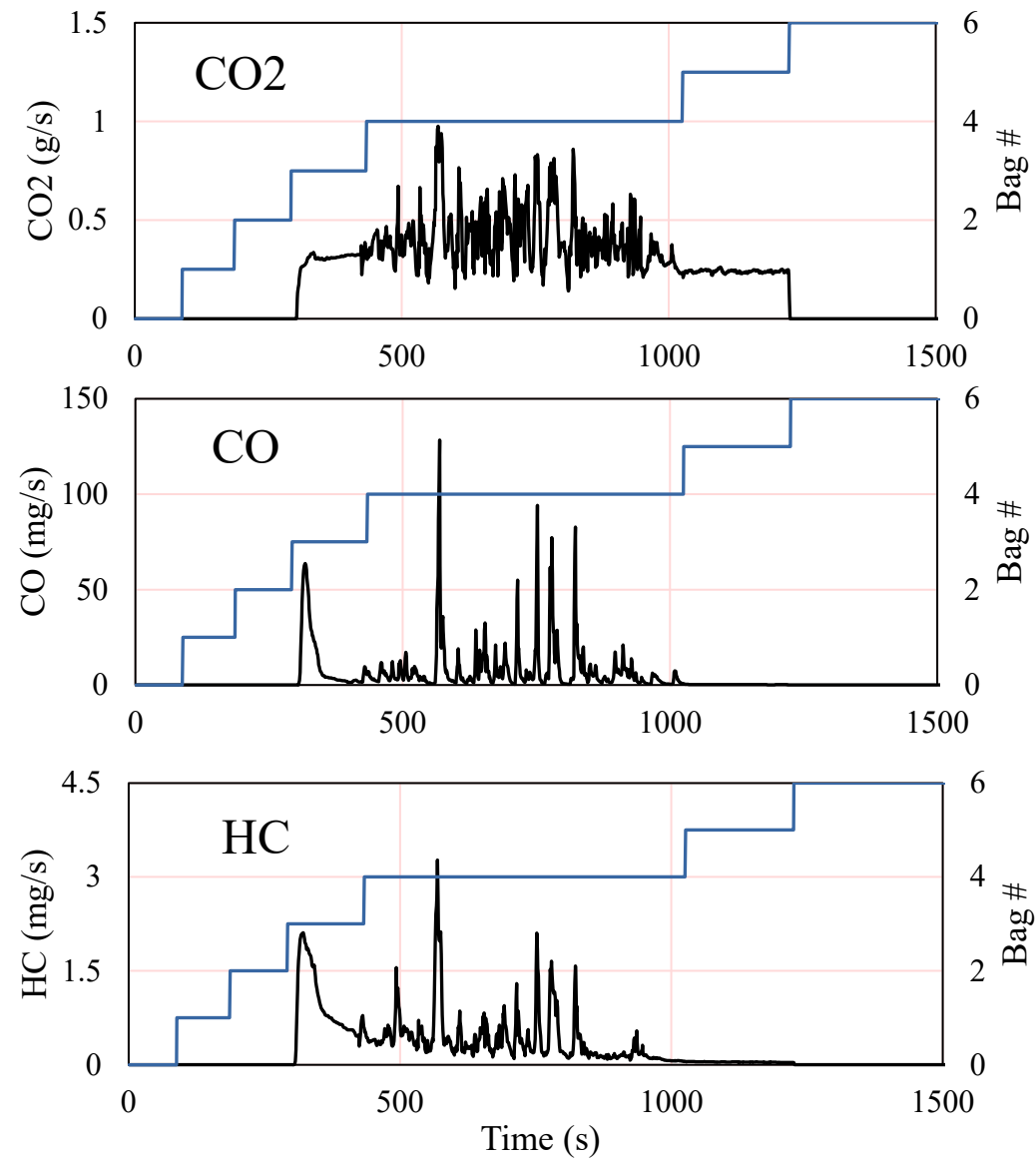
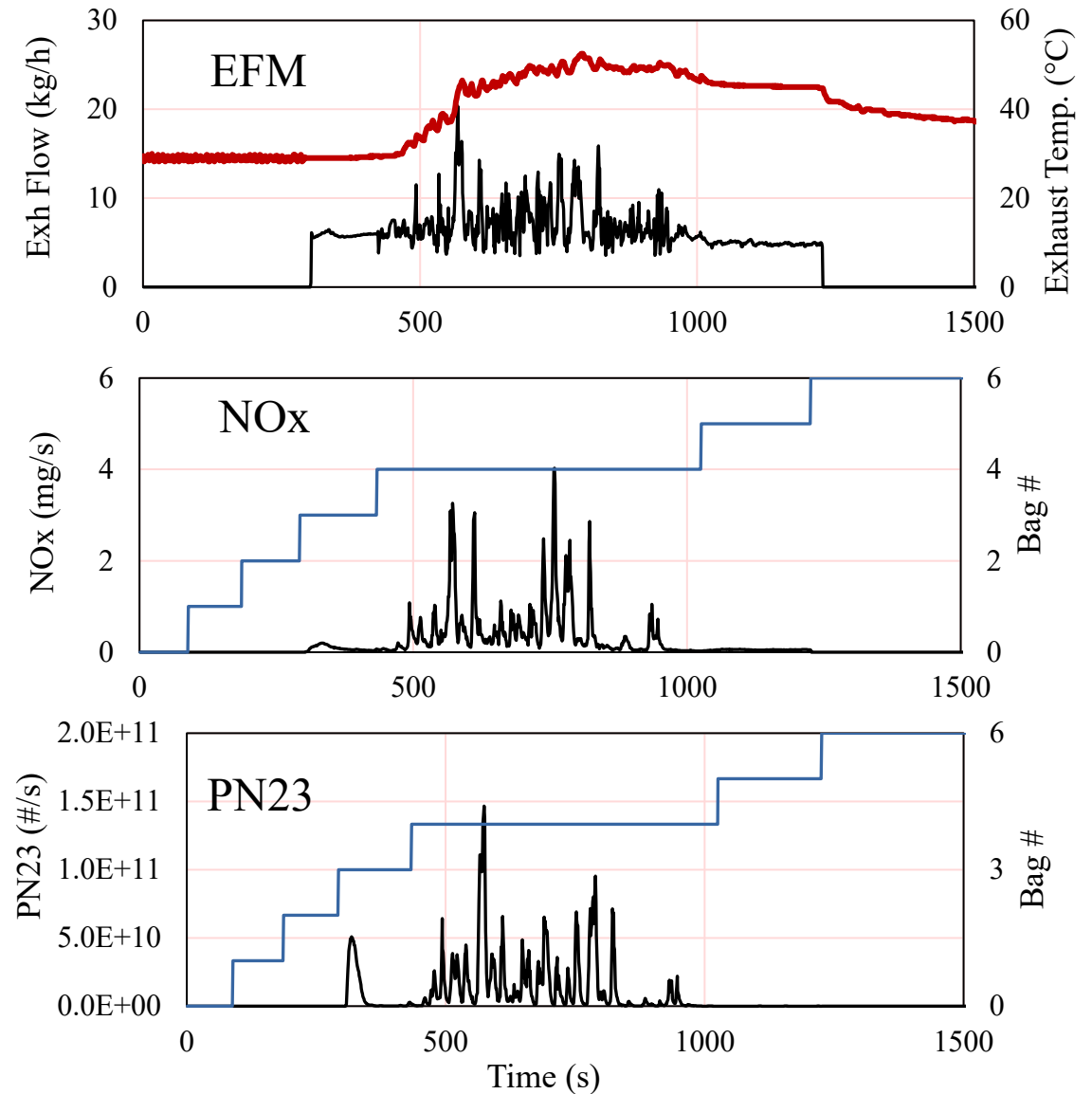
Test	Time (hrs)	Distance (km)	NO2 (mg/km)	NO (mg/km)	NOx (mg/km)	CO2 (g/km)	CO (mg/km)	HC (mg/km)	PM (mg/km)	PN23 (#/km)	PN10 (#/km)
Drive	0.164	2.60	-0.2	103.6	103.4	93.2	1845	90.5	71.7	3.36E+12	3.38E+12
EURO-6D/BS 6 emissions standard			NA	NA	60	est. 35	1000	100	4.5	6.00E+11	NA

The trial demonstrated a complete on-vehicle measurement chain under Indian operating conditions.





Second-by-second data reveals when emissions occur





What motorcycle campaigns have taught us

- A Modular System is essential for scalable programs such as RDE, PUC, and PTI.
- Exhaust flow must be measured appropriately for small engines.
- QA/QC must travel with the measurement system.
- Repeatable workflow matters as much as the analyzer.





The PEMS device is only the first part of the challenge!

MEASURE → DEPLOY → CONTROL → SCALE

MEASURE

Gases
NO / NO₂
PN
Exhaust flow

DEPLOY

Mounting
Power
Calibration
Vehicle changeover

CONTROL

QA/QC
Data synchronization
Validity
Remote oversight

SCALE

Multiple vehicles
Multiple crews
Multiple locations
Comparable data



Equipment feasibility ≠ deployment feasibility!





Field deployment requires a system, not simply an instrument

103 vehicles | 5 days | 2 miniPEMS systems

- Standardized routes
- Local personnel
- Field calibration + QA/QC
- Centralized data handling

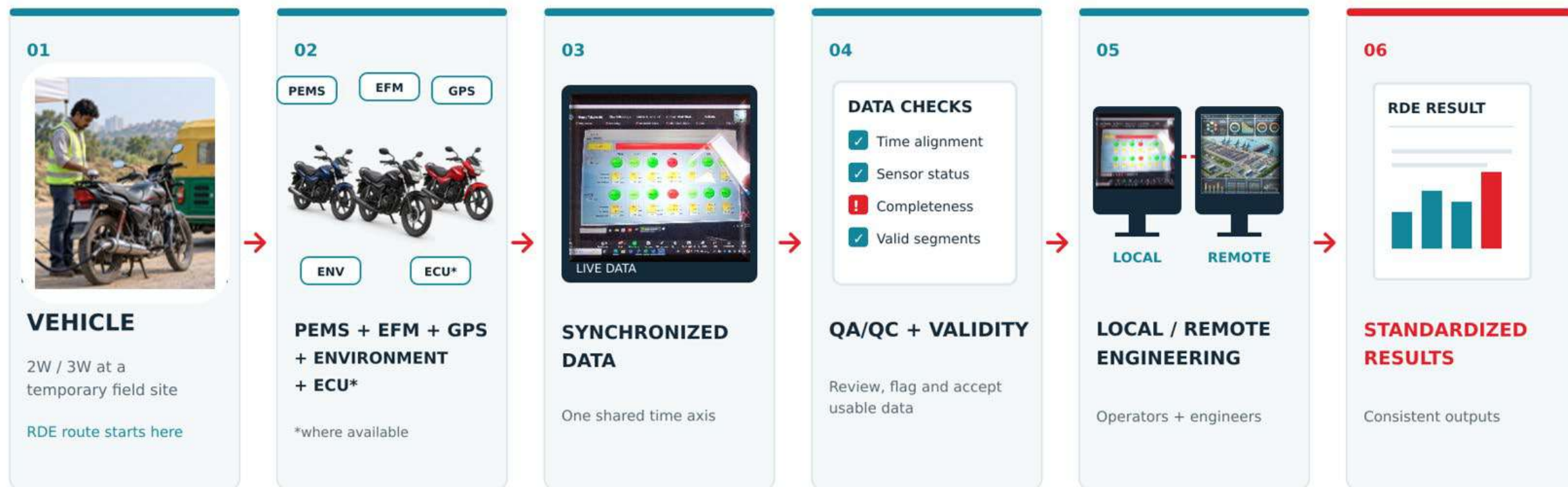




Software turns individual tests into a measurement program

From field test to standardized RDE results

India 2W / 3W: temporary test site, on-road measurement and engineering review



Abuja field model → India 2W / 3W RDE deployment

Temporary site, local operators, synchronized data and remote engineering review. Conceptual illustration.



The remaining challenges are system-level challenges

Packaging

Secure mounting, heat management, weather protection and rider safety

Power

Battery endurance and avoiding dependence on limited vehicle electrical capacity

Flow

Pulsation, condensation, leaks and signal alignment

Representativeness

Added mass, route design, rider behaviour and traffic variability

Quality assurance

Calibration, drift, data completeness and documented processing





3DATX's commercially available **parSYNC® FLEX or FLEX-PNC** is **Pilot-Ready** meeting the following criteria:

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Packaging

Safe & lightweight secure mounting with a reflective weather protection cover for operating at up to 42 C in real driving conditions

Power

Battery power independent to vehicle electrical supply provides 1.5-to-4-hour endurance with hot swap capacity for unlimited endurance

Flow

Mini-EFM tested without pulsation, condensation, or leaks. vTRAQ software package provides signal alignment and mass emissions results

Representativeness

Added mass under 35 kg for compliant testing according to required route design and integrating rider behaviour and traffic variability

Quality assurance

Compliance testing procedures for calibration and drift verification, Procedures for data verification and documented processing





BS VII - from technical feasibility to practical field methodology

DEFINE

Specify vehicle installation, route, boundary conditions, QA checks and data validity.

PILOT

Test diverse two-wheelers in multiple Indian regions and compare selected runs with laboratories.

REFINE

Use pilot evidence to finalise exhaust-flow, PN, data processing and acceptance requirements.

SCALE

Apply validated miniPEMS methods to development, surveillance and in-use programs.





Conclusion

From Exclusive Capability to Real-World Coverage

BS VII needs more than a few expensive systems in a few laboratories.

Large PEMS Systems Keep Scalability Exclusive



VALIDATION
ENABLES
SCALABLE
REAL-WORLD
MEASUREMENT

Validated miniPEMS Enables India-Wide Real-World Coverage



Compact,
vehicle-ready
miniPEMS

Real-world
data across
many locations

Many vehicles
and riders
(110–1,300 cc)

Repeatable,
comparable
data at scale

Lower cost
per test and
faster deployment

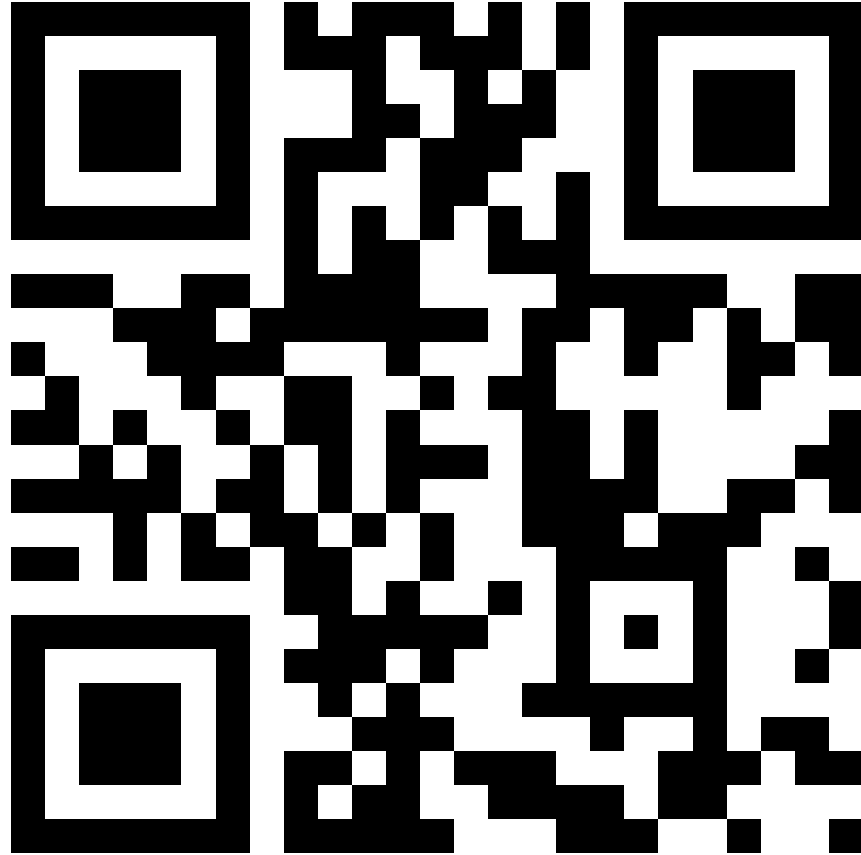
The laboratory establishes confidence. The field creates scale.

Scalable miniPEMS provides the practical path to making BS VII real-world emissions measurement truly real-world.

The next challenge is not simply selecting a PEMS!



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