## 5.2 MM FOR ENERGY EFFICIENCY

### Technology Description

**Introduction**

If measuring and monitoring (MM) for energy efficiency must be able to estimate impacts from mitigation actions at the level of corporations or sectors of usage, then MM must have the ability to quantify reductions in emissions at the point of energy usage through measurement or rules-of-thumb. The primary targets are transportation, buildings (commercial and residential), and industrial processes. The MM challenges significantly overlap needs in other technology areas. For example, the challenges in point and diffuse sources MM as part of "Other GHG" applies to energy efficiency, but with a focus on $CO_2$. The point sources are industrial facilities, while the diffuse sources are primarily vehicles.

**System Concepts**

- Continuous emission monitors (CEM) for point sources with data transmission and archiving complemented by inventory-based reporting so as to be able to evaluate the success of specific actions to improve efficiency.
- For transportation, the systems could include: (1) testing at point of production and applying assumptions to actual performance, (2) on-board emission sensors with data transmission, and (3) local-scale sensors that function autonomously with data transmission so as to homogenize emissions in an area (must also have sensors to track number/type of vehicles).
- Testing of equipment for residential and commercial usage (appliances, HVAC) at point of production; possibly with future sensors to monitor actual performance with data transmission (used for some installations, not feasible for all homes).
- Testing of equipment for industrial processes (e.g., industrial boilers and furnaces) at point of production; possibly with wireless sensors and data transmission capability.

**Representative Technologies**

- CEM for $CO_2$ (linked with energy use statistics at a facility).
- Direct measurement, or indirect measurement via tracer studies, over landscapes (for vehicle emissions); infrared, lidar, etc.
- Test systems at point of production, complemented by testing actual use for some percentage of installed systems.

**Technology Status/Applications**

- CEM are well developed, but improvements in performance, longevity, autonomous use, and data transmission are needed.
- Local-scale systems generally not available, although concepts are being developed and tested at the research stage (e.g., isotopic indicators of $CO_2$ sources).
- Testing at point of production well established; methods to track actual performance autonomously not available.

### Current Research, Development, and Demonstration

**RD&D Goals**

- Develop sensors and data transmission systems that allow quantification of emission reductions resulting from energy efficiency improvements.

**RD&D Challenges**

- Develop CEM that are robust, inexpensive, accurate, and operate autonomously with data transmission.
- Demonstrate tower- or satellite-based sensors to measure $CO_2$ and other GHG at local scales.
- Data fusion with remotely sensed imagery and Geographic Information Systems (GIS).
- Determine whether tracer/isotopic methods can identify source of $CO_2$ and other GHG at local-to-regional scales.
- Develop sensors for vehicles and appliances to measure energy use and emissions with data transmission.
- Develop emissions estimates from the combustion of noncommercial fuels (propane, wood, landfill gas).

**RD&D Activities**

- High-temperature $NO_x$, $O_2$, ammonia, and other sensors are under development.
- Engine diagnostics and controls.
- Fast-response mass spectrometers are being developed.
- A field laboratory that uses state-of-the-art FM-AM-LIDAR for remote monitoring of truck emissions (NOX, PM) and engine performance has been established in Knoxville, Tennessee.

**Recent Progress**

- Examples of new R&D results related to sensors, estimation methods.
- Development of robust, wireless sensors and data transmitters for use in high-temperature, caustic industrial environments (e.g., steel mills, pulp and paper industry).
- Development of the International Measurement and Verification Protocol for estimating energy savings.

**Commercialization and Deployment Activities**

- Activities are focused on deployment of new technologies, and measures of performance are typically comparisons of energy used. Limited use of sensors and data transmission directly for MM purposes.