Key Recommendation 9.0: Environmental Monitoring

[Key recommendation text is still being developed.]

Supplemental Recommendation 9.1: The federal government should establish or encourage IoT environmental data repositories in support of open, available data. Promoting the open availability of data would promote research, improve transparency, and encourage proactive improvement by industry participants. As described in other recommendations throughout this report, improved interoperability and competitiveness will help benefit all IoT adopters, and an open model for shared and consistent data will help take strides toward those objectives.

Supplemental Recommendation 9.2: The federal government should facilitate and support the research, development and deployment of low cost Air Quality sensors. (Could we expand to additional types of monitoring?)

The Board observed that there is a need to shift from expensive (i.e., highly sensitive regulatory grade) sensors that limit deployment by organizations and municipalities. While such sensors are vital for particular monitoring purposes, large scale deployment of these types of monitoring equipment would be expensive and difficult.

Encouraging development and implementation of local, scalable air quality monitoring would support a variety of use cases, including:

- Increasing public awareness of air quality conditions;
- Informing environment and public policy, including through real time testing and demonstration of policy impacts;
- Environmental justice work;
- Supplementing regulatory grade sensing with IoT commercial sensors;
- Public health research;
- Construction site emissions monitoring; and,
- Rapid or emergency air quality monitoring for particular circumstances.

Currently, regulatory monitoring is often limited to a few pollutants; the government can encourage expanded coverage of other emerging chemicals of concern (including greenhouse gasses) in monitoring and sensing systems.

Agencies should encourage automated and consistent measurement and can facilitate research in low-cost sensing technologies for criterial pollutants, such as optical particle scanning for particulate matter and M0x elements for gases and detection of other emerging chemicals of concern.

The government should facilitate the expansion of wireless connectivity to support remote monitoring and sensing in areas not serviced by traditional connectivity. This recommendation supports (and is supported by) those described in Recommendation 4.

Previous Draft material for 9.0: Environmental Monitoring

Recommendation 1: The federal government should facilitate and support the development and adoption of low cost AQ monitoring sensing systems..

Description:

IoT sensing allows for the effortless collection of data from multiple devices and technical innovation in IoT has emerged in research communities worldwide, which together provide new opportunities for low-cost, high resolution, environmental monitoring. However, wider implementation of such devices in the United States will require the approval and encouragement of the federal government.

Justification:

- Regulatory grade sensors are expensive, limiting the number that can be deployed. Their purpose is specific to looking at broad air quality of an area and compare against EPA levels to protect health and welfare (epidemiological reasons). This limits the scaling of AQ monitors
- Metal Oxide (MOx) devices are not as accurate as PID instruments; however, are excellent for the purpose of initial reconnaissance of VOC levels;
- Optical particle scanning for particulate matter and M0x testing for VCs are economical IoT technologies which could augment federal FRM FEM monitoring for NAAQS and NESHAP air pollutants;
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- Gap in local (community) scalable air quality monitoring to support a variety of use cases, including
    - Increasing public awareness of AQ
    - Informing environment and public policy; real time testing of policy impacts
    - Environmental justice work
    - Supplementing regulatory grade sensing with com sensors
    - Public health research
    - Construction site emissions monitoring
    - Rapid or emergency AQ monitoring

Implementation Considerations:

- The EPA should consider amendments to the Code of Federal Regulations 40 Part 50, to encourage implementation of IoT AQ sensing devices to augment regulatory FRM and FEM Methods for air quality monitoring.
- Need top down demonstration by EPA, as well as concrete policy methods, by which to improve implementation of IoT devices and incorporate this data into government data.
- Facilitate research in low-cost sensing technologies for criterial pollutants, such optical particle scanning for particulate matter and M0x elements for gases, as well as detection of emerging pollutants of concern.
- Facility the use of space at federal infrastructure (e.g., post office buildings) and federal assets (e.g., post office delivery vehicles) for locating academic and private sector air quality monitors.

- Facilitate and support research and a program in correlating regulatory grade data with low cost AQ data
    - Push state/city to
- Facilitate the expansion of wireless connectivity to support remote monitoring and sensing in areas not serviced by traditional connectivity (TV white space, satellite, etc.)

Potential implementation barriers:

- Different federal agencies (e.g., EPA, BLM, US Forestry Service) have adopted IoT monitors and different ways and can have different protocols for interpreting the same raw data. Consistent standards for interpreting IoT monitoring data will be needed
- Federal policies take time to be implemented at a state and local level. Funding must accompany IT device related policy statements.
- The Code of Federal Regulations is changed by request of regulatory agencies. The EPA changes slowly by its nature;

Possible participating agencies:

- The EPA; DoC, FCC, NIST.

Recommendation 2: The federal government should consider establishing data repositories for privately collected data

Description:

The growth in IoT devices portends a rapid deployment of devices. These devices have the potential to provide a strong public good, however without transparency privacy and data ownership issues may arise. Additionally, the use of different technologies and methodologies across different platforms may result in conflicting measurements, fostering misinterpretation and reducing public confidence in the monitoring process.

Justification:

- Federal data repositories provide transparency and the opportunity to community reseach to conduct analysis on the data far beyond the capabilities of a single federal agency

Implementation Considerations:

- Consider DOE EIA sharing of power plant data as a possible implementation template

Potential implementation barriers:

- Data should be directly from devices to minimize any differences in post processing

Possible participating agencies:

- The EPA, DOE, DoC, NIST

Recommendation 3: The federal government should consider establishing stockpile reserves of IoT monitoring equipment for quick short-terms deployment during emergency and catastrophic event scenarios

Description:

IoT devices are being develop for mid to long term monitoring of various environment conditions, but the low barriers to cost and deployment create new opportunities to use IoT monitors for assessing environmental conditions after emergency events, such as after fires, floods, industrial accidents.

Justification:

- IoT device deployment can help quickly assess safety concerns through quick deployment with relatively minimal time and effort

Implementation Considerations:

- Consider sharing stockpile across agencies
- IoT devices should be updatable during storage for quick delopyment

Potential implementation barriers:

- Purchase, storage, and use represent new agency costs

Possible participating agencies:

- The EPA, DHS, FEMA

Recommendation 3: Implement a Nationwide IoT-based Water Monitoring Infrastructure

Description:

- Develop a comprehensive, nationwide water monitoring infrastructure that leverages IoT technology for real-time, accurate, and cost-effective water quality and quantity data collection. This infrastructure should support data-driven decision-making, address the challenges of water scarcity, contamination, and climate change, and integrate with existing NOAA water models for enhanced forecasting and management capabilities.

Justification:

- Current water monitoring systems are often fragmented, inefficient, and insufficient to address the growing challenges of water management.
- IoT technology enables real-time, remote, and continuous data collection, allowing for proactive responses to water-related issues.
- Integration with NOAA water models can enhance forecasting and management capabilities, leading to more effective water resource planning and allocation.
- Efficient water management is crucial for consumption, agriculture, and industry, ultimately contributing to environmental and economic sustainability.

Implementation Considerations:

- Develop a standardized, nationwide framework for water monitoring, including protocols for data collection, transmission, storage, and analysis.
- Encourage the adoption of open data standards and APIs to ensure interoperability among different IoT devices, platforms, and NOAA water models.
- Allocate resources for research and development of advanced IoT sensors, data analytics tools, and communication networks that can seamlessly integrate with NOAA's existing water modeling systems.
- Support pilot projects that demonstrate the potential of IoT in water monitoring and management, as well as the successful integration with NOAA water models, and scale up successful models through federal and state programs, grants, and incentives.

Potential Implementation Barriers:

- Diverse geographical, environmental, and regulatory factors may present challenges in the implementation of a nationwide water monitoring infrastructure.
- Ensuring data privacy and security in IoT-based systems may require significant investments in cybersecurity measures.
- Achieving widespread adoption and integration of IoT-based water monitoring systems with NOAA water models may be met with resistance from stakeholders who are accustomed to traditional monitoring methods.

Possible Participating Agencies:

- Environmental Protection Agency (EPA), National Oceanic and Atmospheric Administration (NOAA), United States Geological Survey (USGS), Department of Agriculture (USDA), Department of Energy (DOE), and National Institute of Standards and Technology (NIST).

Recommendation 4: Utilize IoT Technologies to Estimate and Mitigate Carbon Emissions in Farms

Description:

Promote the adoption of IoT-based solutions in the agricultural sector to accurately estimate and manage carbon emissions in farms. By leveraging IoT technologies in conjunction with other methods, farmers can monitor greenhouse gas emissions, implement effective mitigation strategies, and contribute to national and global efforts to reduce carbon emissions.

Justification:

- Agriculture is a significant contributor to greenhouse gas emissions, including carbon dioxide, methane, and nitrous oxide, which contribute to climate change.
- Accurate monitoring and estimation of carbon emissions in farms can help identify emission hotspots and develop targeted mitigation strategies.
- IoT technologies enable real-time, remote, and continuous data collection, allowing farmers to manage emissions more effectively and sustainably.
- Combining IoT-based monitoring with other estimation methods can improve the accuracy and reliability of emissions data.

Implementation Considerations:

- Develop a standardized framework for the integration of IoT technologies in agricultural carbon emissions monitoring, including protocols for data collection, transmission, storage, and analysis.
- Encourage research and development of advanced IoT sensors and data analytics tools specifically designed for estimating greenhouse gas emissions in farms.
- Support pilot projects that demonstrate the potential of IoT in estimating and mitigating carbon emissions in the agricultural sector, and scale up successful models through federal and state programs, grants, and incentives.
- Provide training and technical assistance to farmers and other stakeholders in the implementation and maintenance of IoT-based carbon emissions monitoring systems.
- Facilitate collaboration and data sharing among farmers, researchers, and policymakers to promote informed decision-making and the development of best practices for emissions reduction.

Potential Implementation Barriers:

- The diverse nature of agricultural practices and environmental conditions may present challenges in the development and implementation of standardized IoT-based solutions for carbon emissions monitoring.
- Achieving widespread adoption of IoT technologies in the agricultural sector may be met with resistance from stakeholders who are accustomed to traditional monitoring methods.
- Ensuring data privacy and security in IoT-based systems may require significant investments in cybersecurity measures.

Possible Participating Agencies:

United States Department of Agriculture (USDA), Environmental Protection Agency (EPA), National Institute of Standards and Technology (NIST), Department of Energy (DOE), and National Oceanic and Atmospheric Administration (NOAA).

Recommendation 4a (upleveled version): Utilize IoT Technologies to Estimate and Mitigate Scope 3 Carbon Emissions across economic sectors
Description:
Promote the adoption of IoT-based solutions across multiple economic sector to accurately estimate and manage indirect carbon emissions associated with goods and services. By leveraging IoT technologies, greenhouse gas emissions associated with upstream and downstream supply chains (scope 3 emissions) can be measured, collected, and compiled for the manufacturing, transportation, agriculture production, and end-of-life practices for economic activity. Great transparency of scope 3 emission with enable the implementation of effective mitigation strategies and contribute to national and global efforts to reduce carbon emissions.

Justification:

- Greenhouse gas reporting protocols are recently experiencing increased adoption and many of these reporting protocols include greenhouse gas emissions beyond those associated emitted at the company's site (scope 1) and emissions associated with the generation electricity that the company consumes (scope 2). These indirect, "scope 3" emissions can be challenging to monitor since they are distributed across supply chains of products and services a company uses (e.g, the transportation of the company's product)
- Accurate monitoring and estimation of scope 3 carbon emissions across economic sectors can help identify indirect but significant emission hotspots and develop targeted mitigation strategies.
- IoT technologies enable real-time, remote, and continuous data collection, allowing for systematic management of carbon emissions at reduced cost and effort.
- Combining IoT-based monitoring with other estimation methods can improve the accuracy and reliability of scope 3 emissions data.

Implementation Considerations:

- Develop a standardized framework for the integration of IoT technologies in scope 3 carbon emissions monitoring, including protocols for data collection, transmission, storage, and analysis.
- Encourage research and development of advanced IoT sensors and data analytics tools specifically designed for estimating greenhouse gas emissions across supply chains.
- Support pilot projects that demonstrate the potential of IoT in estimating and mitigating carbon emissions across sectors, and scale up successful models through federal and state programs, grants, and incentives.
- Provide training and technical assistance to stakeholders in the implementation and maintenance of IoT-based carbon emissions monitoring systems.
- Facilitate collaboration and data sharing among stakeholds, researchers, and policymakers to promote informed decision-making and the development of best practices for emissions reduction.

Potential Implementation Barriers:

- The diverse nature of different economic practices and environmental conditions across supply chains may present challenges in the development and implementation of standardized IoT-based solutions for carbon emissions monitoring.
- Achieving widespread adoption of IoT technologies across sectors may be met with resistance from stakeholders who are accustomed to traditional monitoring methods.
- Ensuring data privacy and security in IoT-based systems may require significant investments in cybersecurity measures.

Possible Participating Agencies:

United States Department of Agriculture (USDA), Environmental Protection Agency (EPA), National Institute of Standards and Technology (NIST), Department of Energy (DOE), and National Oceanic and Atmospheric Administration (NOAA).

Recommendation #5

The federal government should facilitate and promote the use and integration of IoT technologies to complement and support wide area environmental situational awareness capabilities to monitor and inform on a variety of environmental conditions and hazards in environmentally sensitive areas.

Description

The use of proprietary technologies and systems are common in systems used to monitor various environmental conditions for first responder, scientific research, and safety applications. The federal government should facilitate and promote the use and integration of IoT technologies to complement and support wide area environmental situational awareness capabilities to monitor and inform on a variety of environmental conditions and hazards in environmentally sensitive areas. Examples of opportunities where IoT technologies should be incorporated include forest monitoring, wildfire monitoring, earthquake detection, flood, air quality, etc.

Justification

Many existing environmental monitoring platforms today use proprietary technologies. One example are the stream gauges used by various federal and state agenices, local governments and private water rights owners to monitor water flow conditions to determine river health and warn on flooding situations. Data collected from proprietary systems are not easily shared nor integrated with data from other sources, thus limiting timely analysis and responsive actions.

Environmental situational awareness monitoring is critical to ecological health, public safety and disaster recovery. For example, a dense network of low cost IoT enabled gas sensors[1] can be used in conjunction with a network of cameras[2] to detect and pinpoint wildfires. Early detection of wildfires in remote forests allows firefighters to direct resources to the initial location, increasing the odds of combating the fire before it becomes widespread. A network of IoT

[1] J. Prisco, "How an 'electronic nose' could help fight wildfires", CNN, November 14, 2022, https://www.cnn.com/2022/11/14/tech/dryad-forest-fire-prevention-spc-intl/index.html

[2] AlertCalifornia, https://alertcalifornia.org/

enabled air quality, earthquake, and other sensors integrated together allow state and regional agencies to build real time situational awareness capabilities to support and plan activities that preserve ecologically sensitive areas, mitigate, respond and recover from natural and man-made hazards.

Implementation considerations

- Specification of IoT technologies into grants and federal procurements for environmental monitoring and situational awareness
- Collaboration with federal, state and regional agencies to define missions and requirements
- Monitoring of wide areas, especially in areas not monitored before or remote areas, may require new connectivity methods, such as satellite and other approaches

Implementation barriers

- Wide area monitoring may span multiple jurisdictions and owners who may have different missions, requirements and goals for monitoring that may not be easily met.
- IoT based sensors may be based on different technologies, which may not meet the users application scenarios, performance requirements, and integration needs.
- Owners/jurisdications may lack the new skills to support, maintain and operate ioT technologies. Skills include integration, data science, cybersecurity, cloud, etc.

Federal agencies

- EPA
- FEMA
- USGS
- US Army Corps of Engineers
- DOI
- US Forestry Service

Federal considerations

- Agencies currently support a number of environmental monitoring platforms or provide environmental monitoring network oversight. For example, the USGS oversees, maintains and operates a nationwide network of 10,000 stream gauges.[3] Agencies need to identify IoT opportunities within those platforms and networks.

[3] Water Resources Mission Area, "USGS Streamgaging Network," USGS, April 27, 2021. https://www.usgs.gov/mission-areas/water-resources/science/usgs-streamgaging-network