Sensors / SmartMeters (Internet of Things)

Source: istock/B4LLS

Photo of a tablet showing an overview of data generated by a sensor network

Relevance of this Tool Type within the Project Cycle

Definition

A sensor is a device that monitors changes by converting signals (input) continuously and automatically from analog objects into a digital interface (output). Technological developments have empowered sensor connectivity through cloud/remote access, forming a global infrastructure of physical and virtual, internet-connected objects called the **Internet of Things (IoT)**. A smart sensor measures and combines signal conditioning and signal processing within one device. For example: a *SmartMeter* monitors electric energy consumption in (near) real-time, communicates with a central system or smart grid, and shares usage data with consumers and providers for billing, data analytics, customer targeting, and rate recommendations. Similarly, a *Smart Water Meter* provides high-resolution readings, demand forecasting, scarcity prevention and leak notification.

Step 1: Check the Legal Framework

Depending on usage and connectivity, sensors may require some regulation to ensure explicit consent and hedge privacy breaches given the growing concerns around fine-grained information collected by smart meters exposing individual behavior (private activity, daily routine, etc.) which need to be proactively accounted for with built-in controls masking personal behavior patterns.

Step 2: What Information Do I Need?

A wide array of sensors and SmartMeters can be used for project management, (remote) monitoring, and verification. Their selection depends on the project's information needs and is mostly sector-specific:

Energy sector

- **Power plants:** remote monitoring (input/output parameter), steering of energy generation, and controling:
  - Sensors measure parameters such as oil, air,and device temperatures, the speed of turning parts (turbine, motors), the physical characteristics and chemical composition of fuels, and gases and exhaust emissions.
  - Sensors measure optical and acoustic parameters, among others, to remotely control power plants that have limited or no operation personnel at the power plant site.
  - SmartMeter data can be used by the energy plant itself to detect/reconfigure and reroute in case of power loss, reducing maintenance costs.
- **Electricity (Smart) Grid:** sensors for measuring conditions in the electricity transmission and distribution grid (e.g., voltage, frequency, temperature, etc.)

- **Energy efficiency and reliability:**
  - Sensors applied to various energy captors/processors (electric/gas generators, water turbines, windwheels, solar panels/street lighting, etc.) measure, monitor, and steer energy sources.
  - Power suppliers use sensors to gather insights and offer incentives to users to use energy at non-peak times to reduce the costs of building greater capacities.

Water sector

- **Wastewater and drinking water treatment plants:** sensors measure water quality and flow to remotely monitor and steer treatment, inlet- and outlet water quality, and support operations.
- **Water and wastewater networks:** sensors are used to monitor network conditions (flow metering and pressure sensors) and steering (via valves, pumps).
- **Meterological and hydrological networks:**
  - Sensors measure hydrological situations (precipitation, evaporation, temperature, river runoff, sunshine hours, etc.).
  - Sensors measure water quality and quantity (levels of groundwater and surface waters in reservoirs and water quality parameters).
  - Remote data transfer (mobile cards, internet), remote control, analysis of the meterological, and hydrological data in computer-based systems.

Mobility sector

- **Network capacity:** sensors monitor load in interconnected charging stations for e-vehicles.
- **Traffic:** sensors can help in incident reporting and response, traffic directions, and parking management. They can also measure air pollution.

Biodiversity/Environment sector

- **Forest and ocean protection:** sensors may be used to stop illegal deforestation, protect endangered species, and track waste dumping.
- **Smart farming:** sensors measure methane levels, air temperature, rainfall, soil moisture, soil pH, etc.

Step 3: What Do I Need to Consider When Acquiring Sensors?

There are many platforms available on/offline for purchase-by-unit. Users may choose sensors based on:

- ✓ **size** (nano, micro, 2D, 3D, etc.)
- ✓ type of **connection**: wired/wireless
- ✓ **functional** requirements (offline usage and range, solarpower, calibration resolution, repeatability, interferences, environmental conditions, maintenance, etc.)
- ✓ **non-functional** attributes (e.g., longevity, interoperability, scalability, wireless protocols, compliance with safety standards, etc.)
- ✓ **costs** (can be mitigated by industry collaboration)
- ✓ **accuracy** as precision requirements often drive up costs exponentially. Sensors often require frequent calibration to assure correct measurements, so you need to check if calibration services are available locally.
- ✓ **disponsability.** Sensors may offer many advantages: low-cost, easy-to-use, short-term or rapid single-point measurements, reliable information and digital connectivity for availability to users and centralized/decentralized facilities.

Procurement of Sensor Data

Sensor datasets are siloed, often proprietary, and treated as the exclusive preserve of the organizations collecting them. However, traffic and meterological data is often available for free (universities/cities).

If the application of sensors is not possible and no publicly available datasets exist or are accessible, the use of tools modeling synthetic datasets can be explored (meaning generated by a computer simulation that approximates real data but is fully algorithmetically generated). Example: https://dweet.io/

Risks and challenges to keep in mind:

- Need for high-quality products to avoid technology distrust and bypassing
- Maintenance processes are dependent on supply chain disruption when replacing spare parts
- Data quality requires expertise to ensure interlinking with multiple data sources.
- Data control requires expertise to avoid security breaches or data leaks in case of unproven encryption methods.

Legal Aspects

Data protection: Smart meters provide insights into the consumption patterns of private households and are thus sensitive in terms of data privacy. Data transmission is only permitted for the applications required for utility industry operations. The use of personal data for other purposes will, depending on the applicable law, require consent from consumers > RMMV Guidebook Section 2.3.1.

In addition, **data security requirements** also arise from national data protection regulations, which stipulate basic security requirements to protect the collected personal data, such as consumption, address, and names. Entities may be required under those rules to ensure the ongoing confidentiality, integrity, availability, and resilience of processing systems and services (technical and organizational measures). They need to ensure that the IT security measures are adequate to withstand attacks from hackers or cyber warfare directed at critical infrastructure > RMMV Guidebook Section 2.3.2.

Project Examples/Use Cases

- In the energy project, Green Energy Corridors in India (GEC; PN: 30420), sensors are used to record data, like voltage or power, which are transmitted to the control system SCADA.
- In the Hydropower and Renewable Energy project in Pakistan (HRE; PN: 27138), sensors are used to monitor offgrid mini-hydropower plants. The open source-based power monitoring software was developed in a GIZ-project.
- In the Hydromet Project in Jordan (Hydromet; PN: 29452), new measuring stations for the collection of hydrological and meteorological data were installed and commissioned. The measuring stations transmit the data via mobile data networks to a control and server room.
- In the Water and Climate Monitoring project II in Sambia (PN: 30888), existing hydrological and meteorological stations were rehabilitated, groundwater boreholes for measuring groundwater were drilled and an Integrated Water Resource Management Information System was established.

Links to Further Sources

- Regulation Framework on Sensor Technologies
  https://link.springer.com/chapter/10.1007/978-1-4302-6014-1_6
- Sensors as new Data Source in DC
  https://merltech.org
- Infrastructure sensing
  https://www.researchgate.net/publication/304065637_Infra-structure_sensing
- Smart metering market trend analysis
  https://www.comserveonline.com/news-releases/middle-east-africa-smart-meters-market-growth-analysis-out-look-by-trends-opportunities-and-forecast/10028252
- Biodiversity applications:
  https://www.techrepublic.com/article/the-internet-of-wild-things-technology-and-the-battle-against-biodiversity-loss-and-climate-change/Disposable%20sensor%20for%20monitoring
- Disposable sensors:
  https://onlinelibrary.wiley.com/doi/full/10.1002/adma.201806739
- Open sensor datasets
  https://data.world/datasets/sensors
- Commercial use of data sets
  https://datarade.ai/data-categories/iot-data

Linkages to other tool types

- Building Information Modeling
- Maintenance Management Systems
- (Remote) Management Information Systems
- Geospatial Tools
- Drones / UAV
- Cameras
- Earth Observation via Satellites
- Data Sources

Further information on how to use this tool type in an RMMV context can be found here: