Making Supplier Energy Waste Streams Transparent

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Motivations and Objectives
- Regulatory agencies and compliance measures have obligated manufacturers to reduce their corporate-wide environmental impact in the recent years, with economic penalties and social stigma otherwise.
- Manufacturers undertake constant, inherent risk of affecting their environmental footprint while they depend on suppliers.
- Frameworks for energy audits are undefined between production enterprises and are dependent on self-reported, unit-inconsistent data by individual suppliers.
- This project aims to develop an energy auditing methodology which enables energy streams to be more transparent for detecting waste points and suggesting improvements.
- This framework may be used in applications such as supplier selection by manufacturers and/or footprint improvements by non-compliant suppliers.

Supplier Google Earth View
- In order to understand and potentially make point-detection of energy wastes, both manufacturers and suppliers can label their energy streams into a energy data hierarchy, analogous to a Google Earth View.
- An energy waste cause can be hypothesized for actual assessment afterward.
- Examples are provided

Parameter Level
- **Detection**
  - Sensors
    - Power Meters
    - Watt node
  - Functional Unit
    - Volume, V [mm³]
  - Parameters
    - Material Removal Rate, MRR [mm³/s]
    - Width of cut, w [mm]
    - Depth of cut, d [mm]
    - Feed rate, f [mm/rev]

- **Suggested Improvement**
  - **Model Characterization**
    - $E = \frac{1}{2}mv^2$
  - **Energy Prediction**
    - $E = \frac{1}{2}mv^2$

- **Tool Path Level**
  - **Detection**
    - Sensors
      - Power Meters
        - Yokogawa, 3P3I3W
    - Functional Unit
      - Volume, V [mm³]

- **Process Level**
  - **Detection**
    - Sensors
      - Watt node / MT Connect
  - Functional Unit
    - Machine Energy Consumption, $E_m$ [J]

- **Suggested Improvement**
  - **Energy Categorization**
    - Processing Energy
      - Process Block Examples
        - Milling
        - Drilling
        - Turning
        - Embedded Energy
  - **Process Chain Level**
    - **Detection**
      - Functional Unit
        - Value-added Time per Machine, $t_{va}$ [sec.]
  - **Example Process Chain**
    - Laser Cutting + GMAW_{metal} + GMAW_{clad} + Hand Grinding
  - **Suggested Improvement**
    - **Process Chain Optimization**

- **Facility Level**
  - **Detection**
    - Functional Unit
      - Factory Energy Demand, $E$ [kJ]

- **Suggested Improvement**
  - **Improved Factor Design and Utility Planning:**
    - Near
      - Equipment Maintenance
        - Ex: Inspect HVAC gasket
    - Long
      - Equipment Upgrade
        - Ex: Waste-heat recovery system

- **Summary and Future Work**
  - Manufacturers must understand their suppliers' energy stream through defined data collection standards in order to make accurate assessments.
  - This study assumed level-discrete energy waste; hence, neglecting data uncertainty based on accuracy nor precision.
  - Users are encouraged to utilize this framework as preliminary point-source detection-to-improvement method.
  - Data uncertainties and error propagation will be considered as part of future work.