Process Trade-off Analysis for Green Manufacturing

**Motivation**
- Manufacturing processes are resource intensive
  - 33% of total U.S. energy consumption occurs in industrial sector
  - 19% of total world global warming potential (GWP) emissions
  - Self-supplied industrial water use is ~4% of total withdrawals

- Estimated untapped potential to increase energy efficiency is 16-22% of the global industrial end-use energy demand

**Goals & Approach**
- Assess resource consumption for multi-station operations using life cycle assessment methodology
  - Energy use
  - Water use
  - Waste
- Develop a tool to provide decision support for manufacturing process and process chain selection for multi-station operations
- The tool can be used to better understand resource consumption and environmental and financial impacts of manufacturing process chains used to make a product

**Process Analysis**
- Each manufacturing process of the process chain has to be analyzed individually
- For each process multiple inputs and outputs will be assessed

**Process Chain Variations**
- Examples of fabrication processes:
  - Plate Steel → Laser Cutting & beveling → Plate Bending → Joint Preparation–Cleaning → Tacking → GMAW welding → Machining
  - Plate Steel → Plasma Cutting & beveling → Plate Bending → Joint Preparation–Cleaning → Tacking → FCAW welding

**Process Chain Analysis**
- Quantifying the energy consumption according to different machine states

**Impact Analysis**
- Energy use
- Water use
- Operating cost
- GWP

**Conclusions & Future Work**
- Comparing different manufacturing processes and process chains can be used to inform trade-off decisions that influence operating costs, resource consumption, and impacts on the environment
- These comparisons could also inform production decisions including:
  - Production location
  - Production floor and line layout
  - Future factory planning
- Production location considerations:
  - Local cost of resources (energy, water, etc.)
  - Carbon intensity of energy mix at production location

**Future Work**
- Define and assess manufacturing processes
- Develop a standard assessment approach for each resource group (water, energy, and waste)
- Develop a software tool to include the assessment and evaluation methodology