Preliminary Thoughts on System Level Decision Support Tools for ESH in Semiconductor Manufacturing

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Overview

- Systems engineering
- ESH challenges
- Semiconductor process network modeling
- Multi-objective optimization
- Potential thrust areas identified
  - Evaluation of new technologies
  - Recycling
  - Mode of operation of tools
- Summary

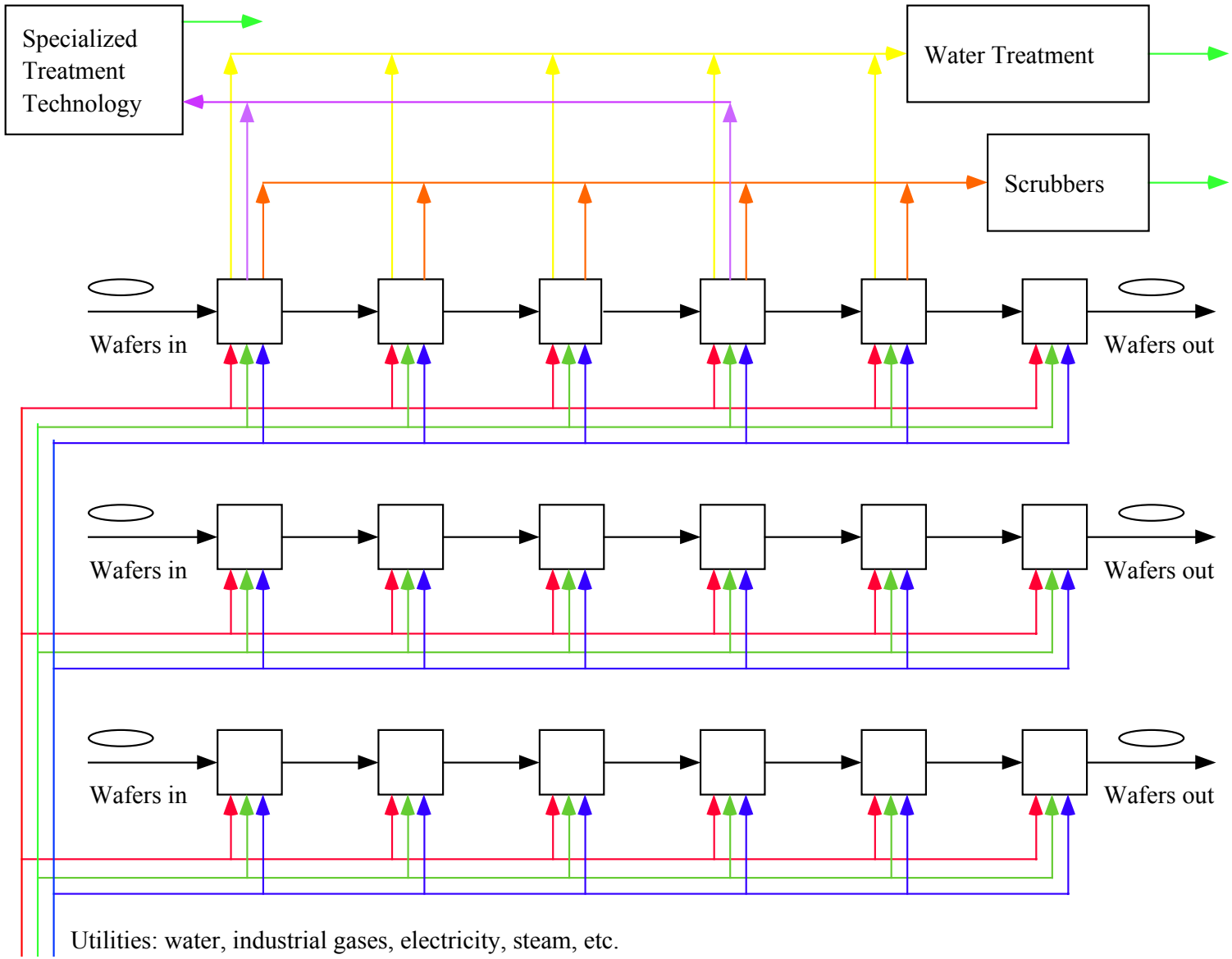
Systems Engineering

- Decision support tools for:
  - Planned R&D
  - Capital investments
  - Holistic approach
- Features
  - System wide approach to integrate decisions throughout the process network
  - Heuristics
    - Thermodynamic insight
    - Hierarchical approaches
    - AI, expert systems
  - Mathematical programming
    - Multi-objective approach to balance economic, quality and environmental considerations
    - Superstructure based

ESH challenges in Semiconductor Manufacturing

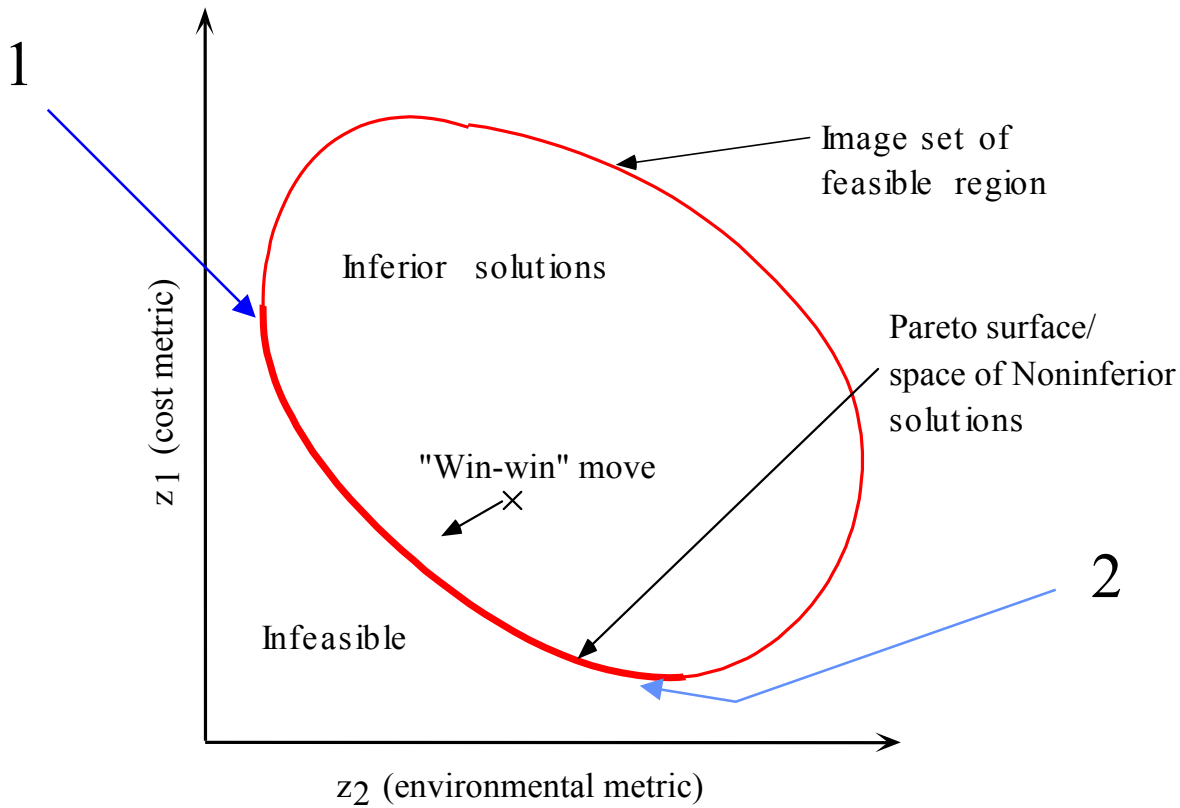
- Very capital intensive industry
- Risk adverse - better safe than sorry?
- Extremely high purity requirements on raw materials
- Activities not driven by environmental legislation (yet)
- Bringing products to marked in a timely fashion critical
- Uncertainties in future marked, prices, legislation, new technologies

Semiconductor Process Network Model



Multi-objective Optimization

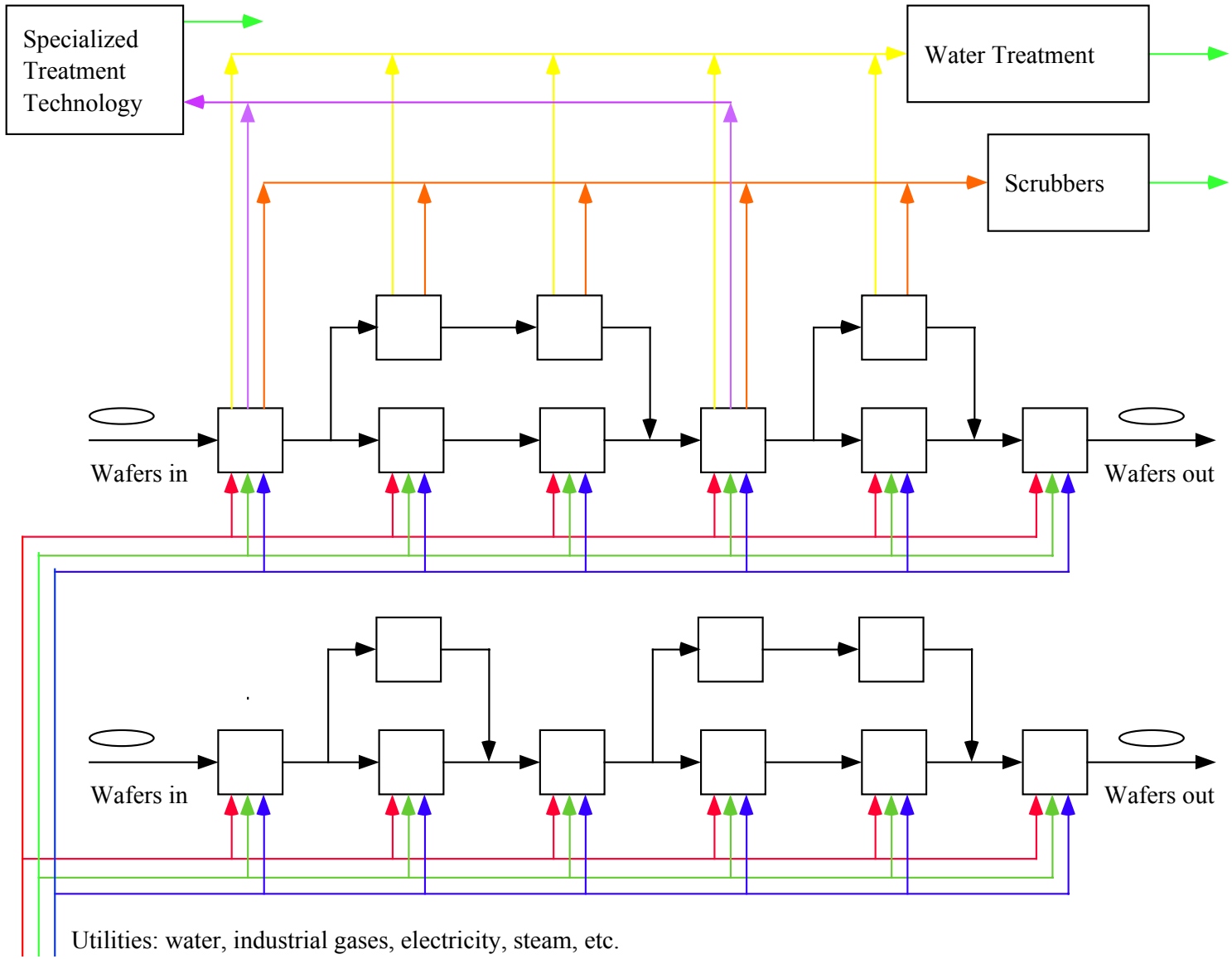
1. Minimum cost given minimum effluents/emissions.
2. Minimum effluent/emissions given minimum cost.



Potential Thrust Areas Identified

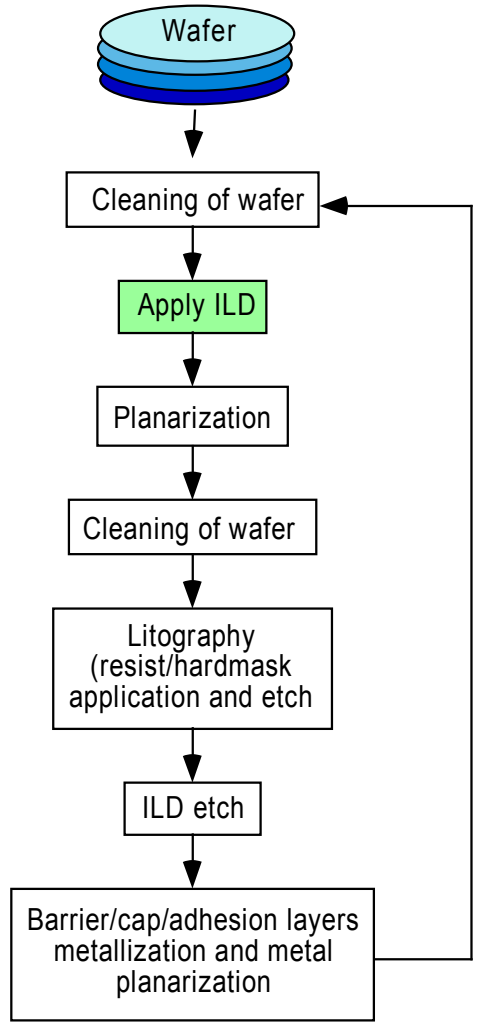
- Evaluation of new technologies
- Assessment of recycling
- Mode of operation of tools

Evaluation of New Technology

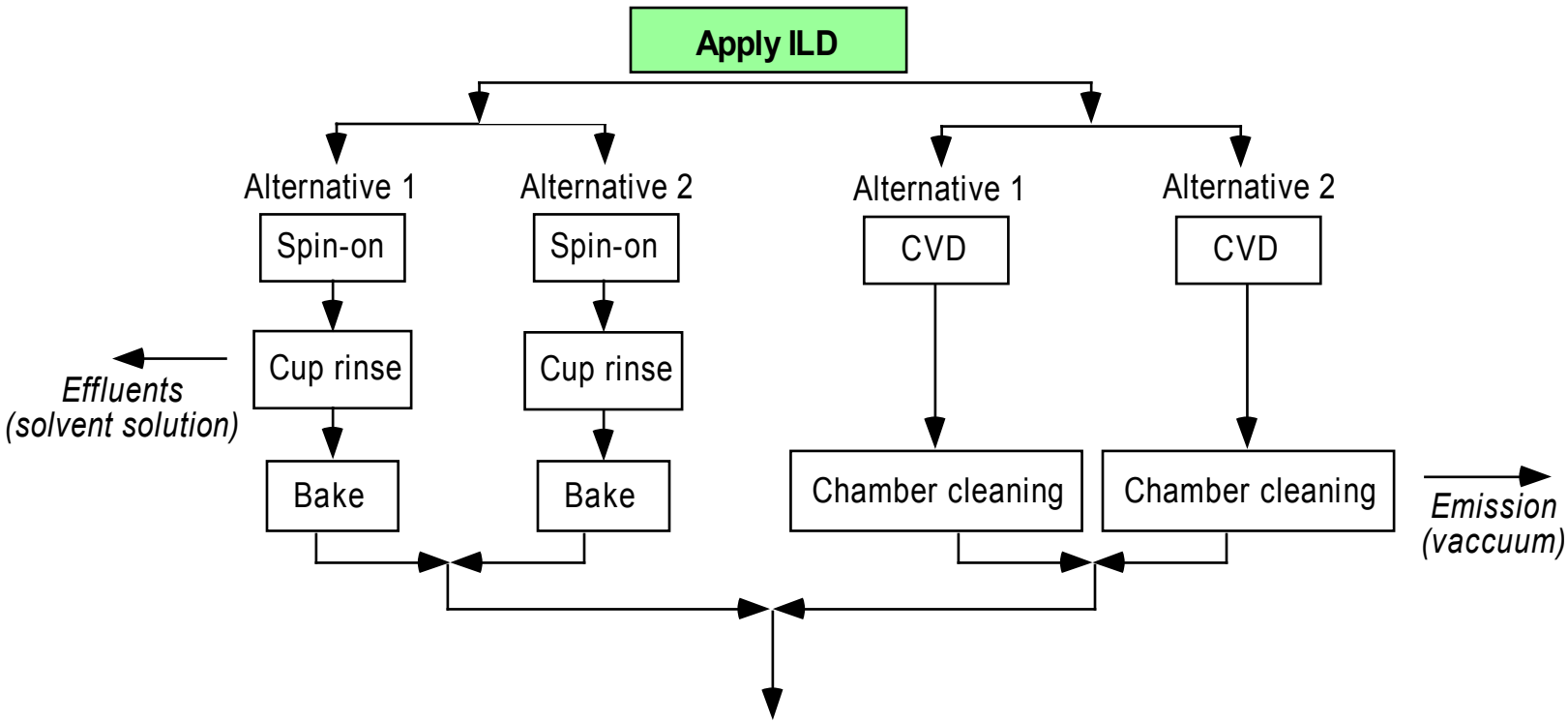


Example

- The problem addressed:
  - Given a subset of tasks/tools in the plasma processing section, select a processing route that satisfies production demand, while minimizing waste generated.
- More specifically:
  - New technologies for interconnect materials less than 0.15µm and hence with dielectric constant κ~2 need to be evaluated.



Example cont.: Superstructure



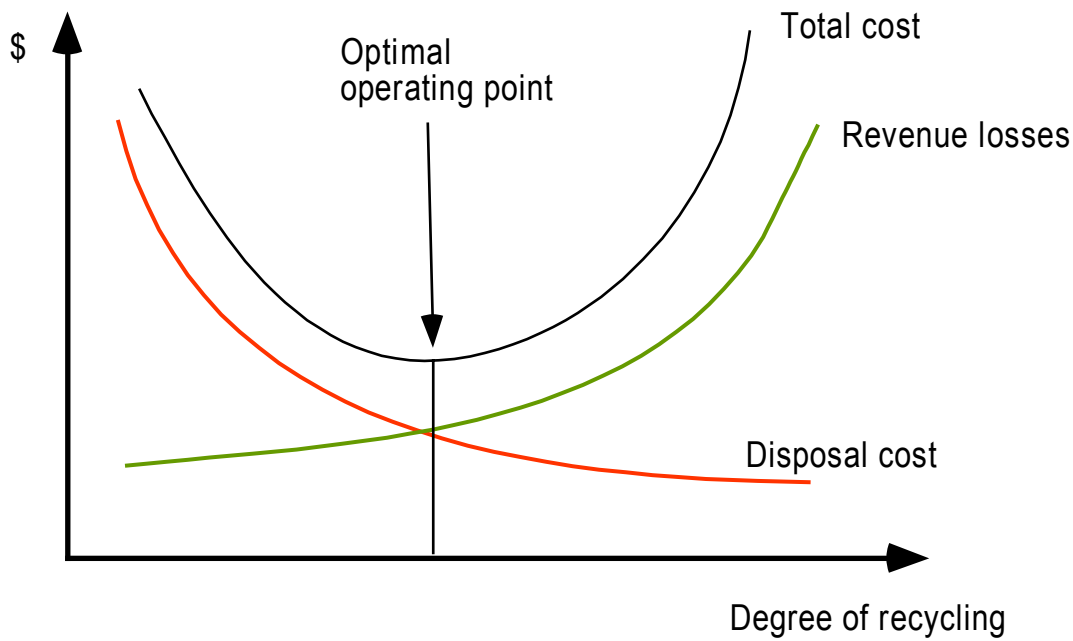
- Evaluate two technologies:
  - Spin-on versus CVD with alternative dielectric materials/precursors for the film

Assessment of Recycling

- Recycling within facility
  - Clean solvent and gases according to most stringent requirements
  - Recycle back to tasks/tools with less stringent requirements
  - Select materials (solvents, acids, gases) with recycling in mind ("design" the waste to be treated)
  - Design process with recycling in mind (single tool may generate less waste, but may overall result in more waste)
- Industrial Symbiosis
  - Collaboration with external facilities for treatment of waste and sale to third parties
  - Again, select materials (solvents, acids, gases) with recycling in mind ("design" the waste to be treated)

Issues to Be Addressed

- Trade-off between benefits from recycling and loss in yield
- Optimal operating point dependent on relative magnitude of yield loss cost, cost of treatment, raw material cost, etc
- Parametric optimization



Mode of Operation of Tools

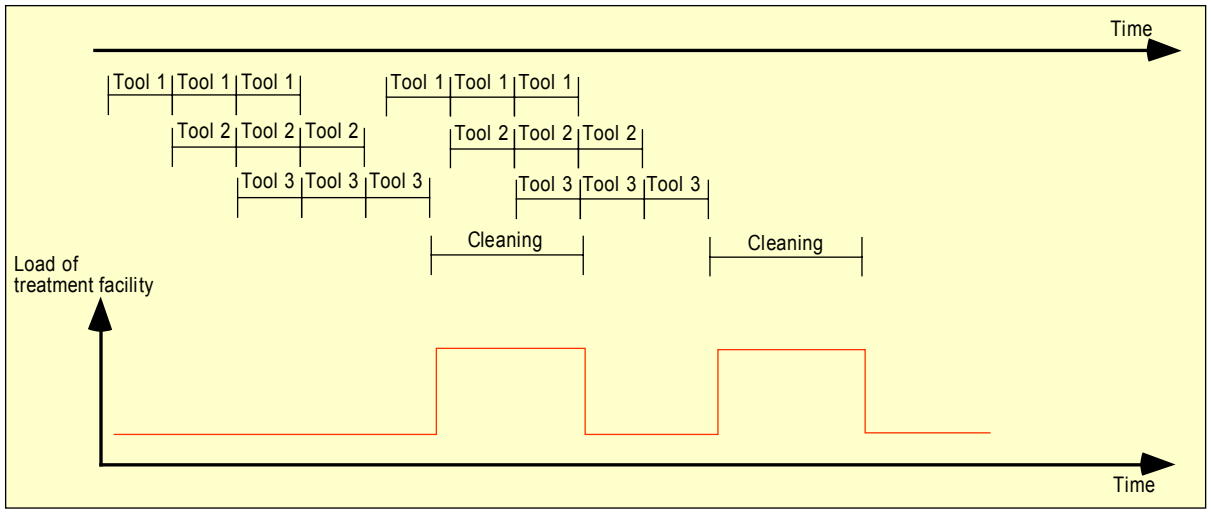
- Cluster tools: single wafer processing
- Wet cleaning: typically batch processing
- Intermixing single wafer and batch processing in single line impacts throughput and tool utilization
- Development of single wafer cleaning:
  - More cost efficient?
  - Lower emissions?
  - How to find out?

Issues to be addressed

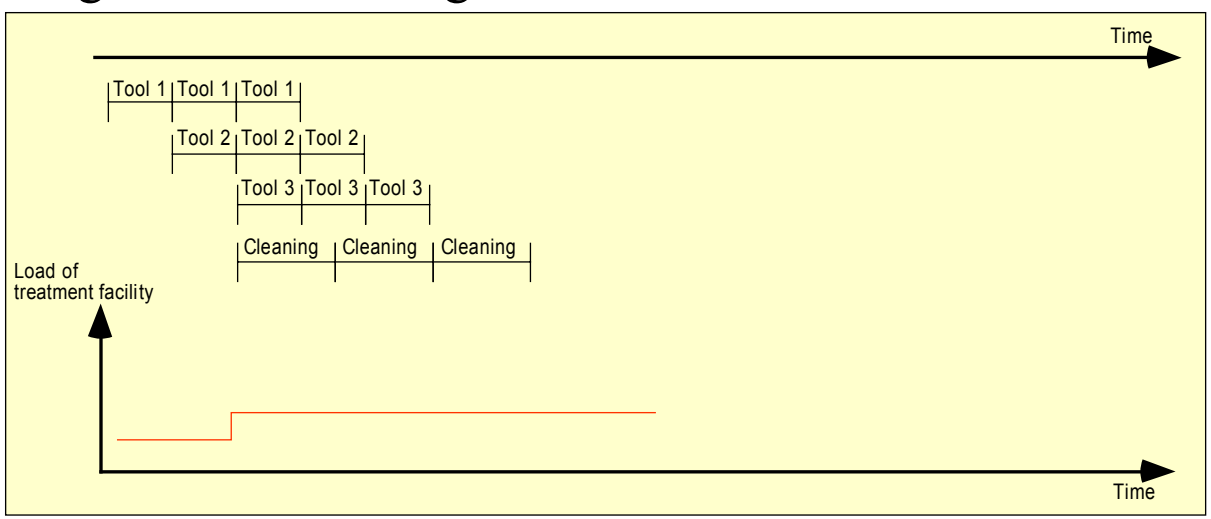
- Optimal scheduling
- Quantifying waste generated
- Assessment of throughput
- Load on treatment facility
- Relate to recycling
- Simpler or more complicated waste treatment?
  - May need multiple treatment facilities

Load on Treatment Facility

Cleaning performed batch wise



Single wafer cleaning



Summary

- Several areas have been identified for application of system engineering
- Determine greatest potential
  - Risk
  - Degree of improvement
  - Cost/Savings