INTERNATIONAL SEMATECH
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ESH Technology Center

Accelerating Sustainable Manufacturing

Status and Needs For Progressing Energy Reduction in Process Tools

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Agenda/Topics

- Definition
- Opportunities for Improvement
- Current/Existing Solutions in Reducing Energy Required by the Process
- Needs
- Next Steps

Merriam Webster Definition - Energy

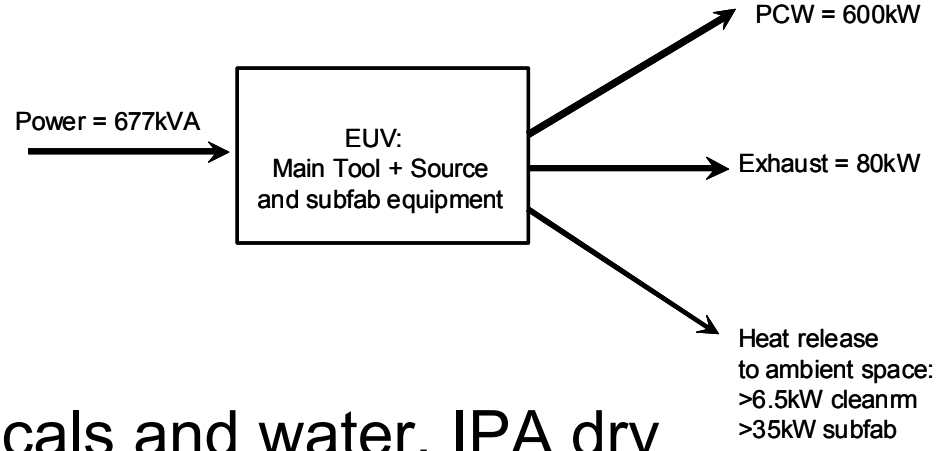
- *Physics* . the capacity to do work; the property of a system that diminishes when the system does work on any other system, by an amount equal to the work so done; potential energy. *Symbol:* E
- 9. any source of usable power, as fossil fuel, electricity, or solar radiation.

Utilities that require energy to provide

- Electricity
- Exhaust
- Bulk gases (i.e. compressed air, nitrogen)
- Bulk chemicals (i.e. IPA)
- Process cooling water
- Ultrapure water
- Specialty gases (i.e. NF3)
- Specialty chemicals (i.e. photoresist)

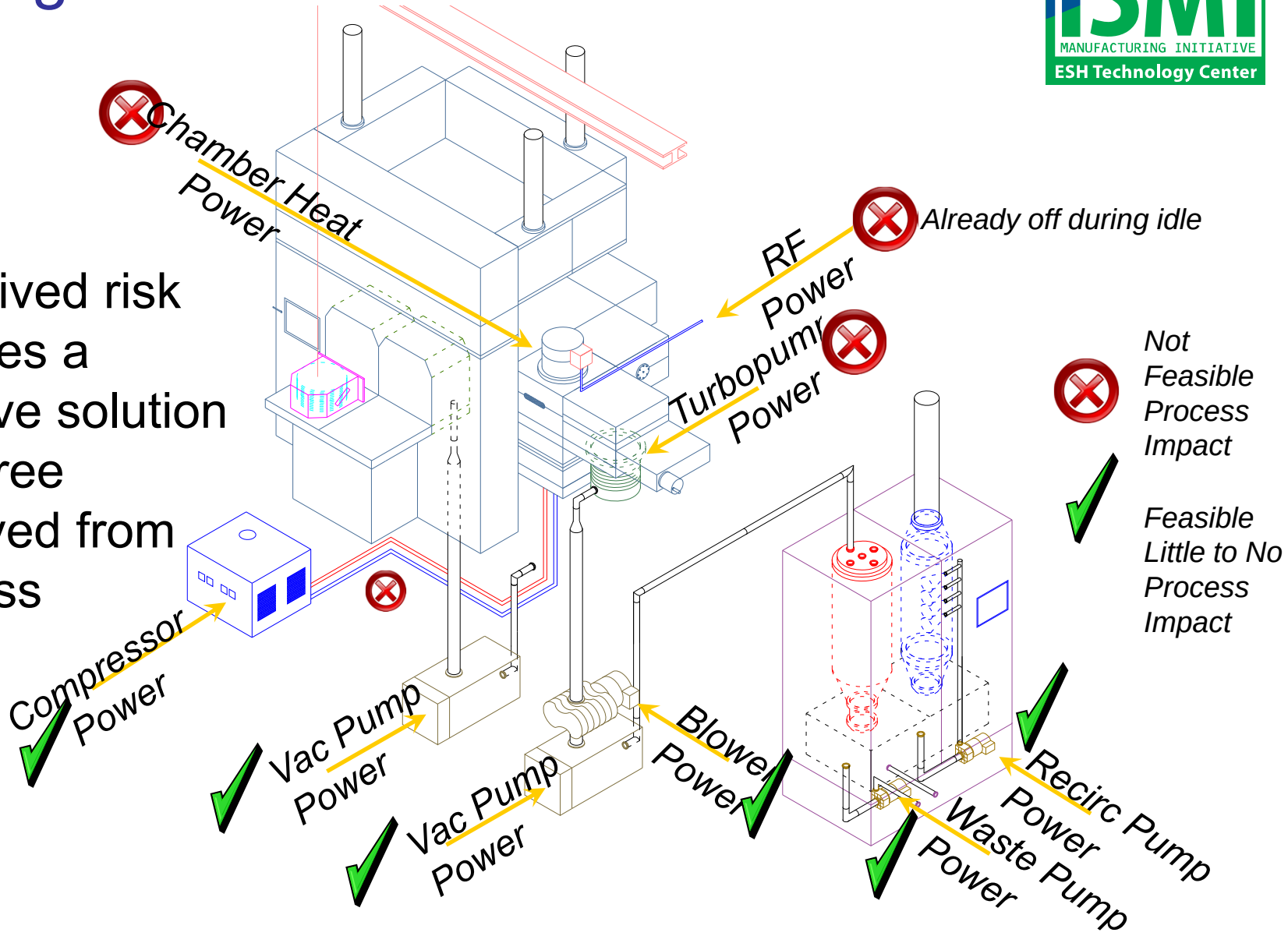
Opportunities For Improvement

- Implant/diffusion – waste heat,
- Litho energy requirements –
  - EUV sources,
  - compressed air,
  - waste heat in water and exhaust,
  - environmental requirements 0.1C/hr,
- Etch/CVD –
  - pumping energy,
  - abatement energy,
  - chamber heating,
  - rf power
- Wets/CMP – heating chemicals and water, IPA dry
- Test/Sort – waste heat for testers

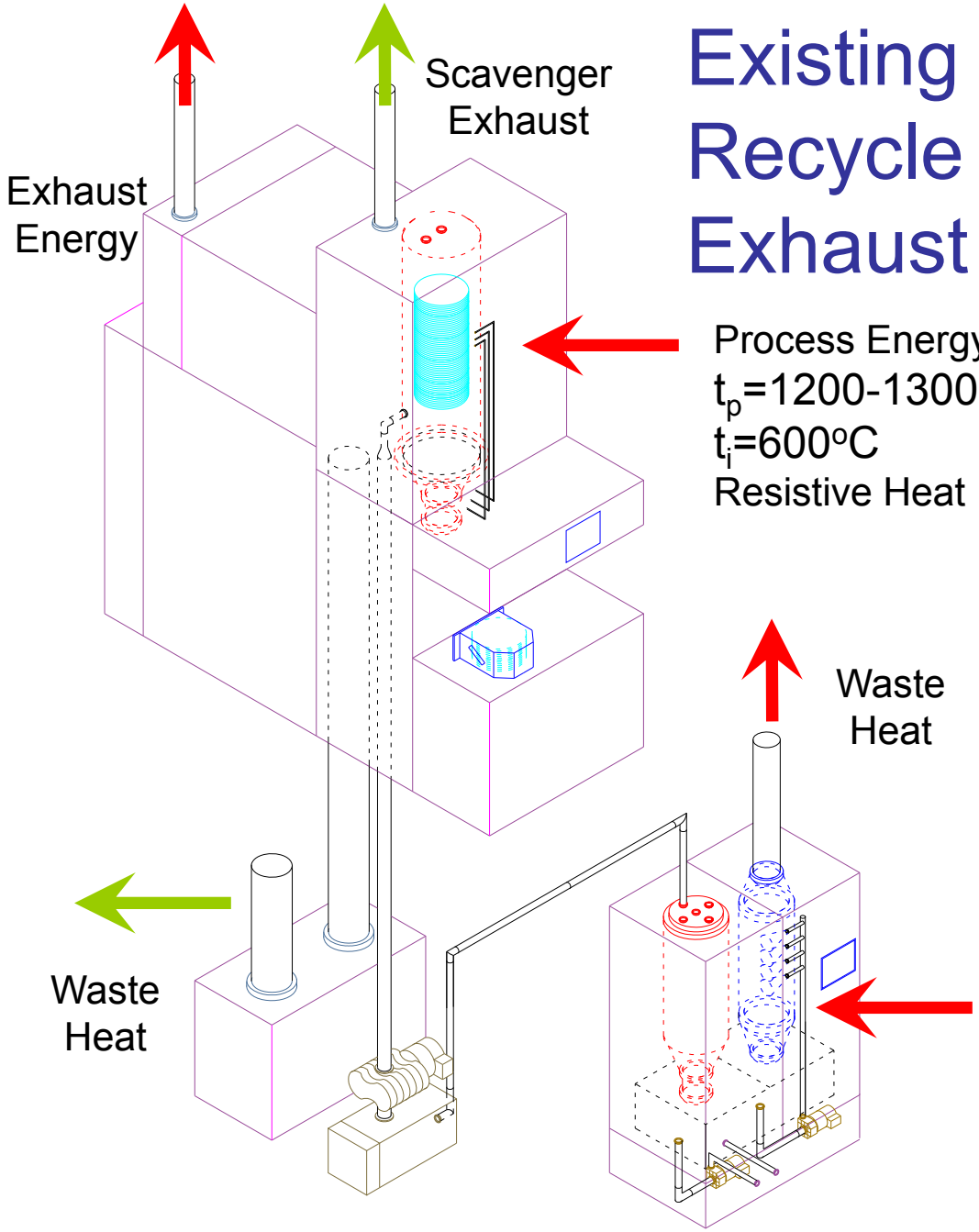


Existing Solution – Reduce in Idle Mode

Perceived risk requires a reactive solution 1 degree removed from process

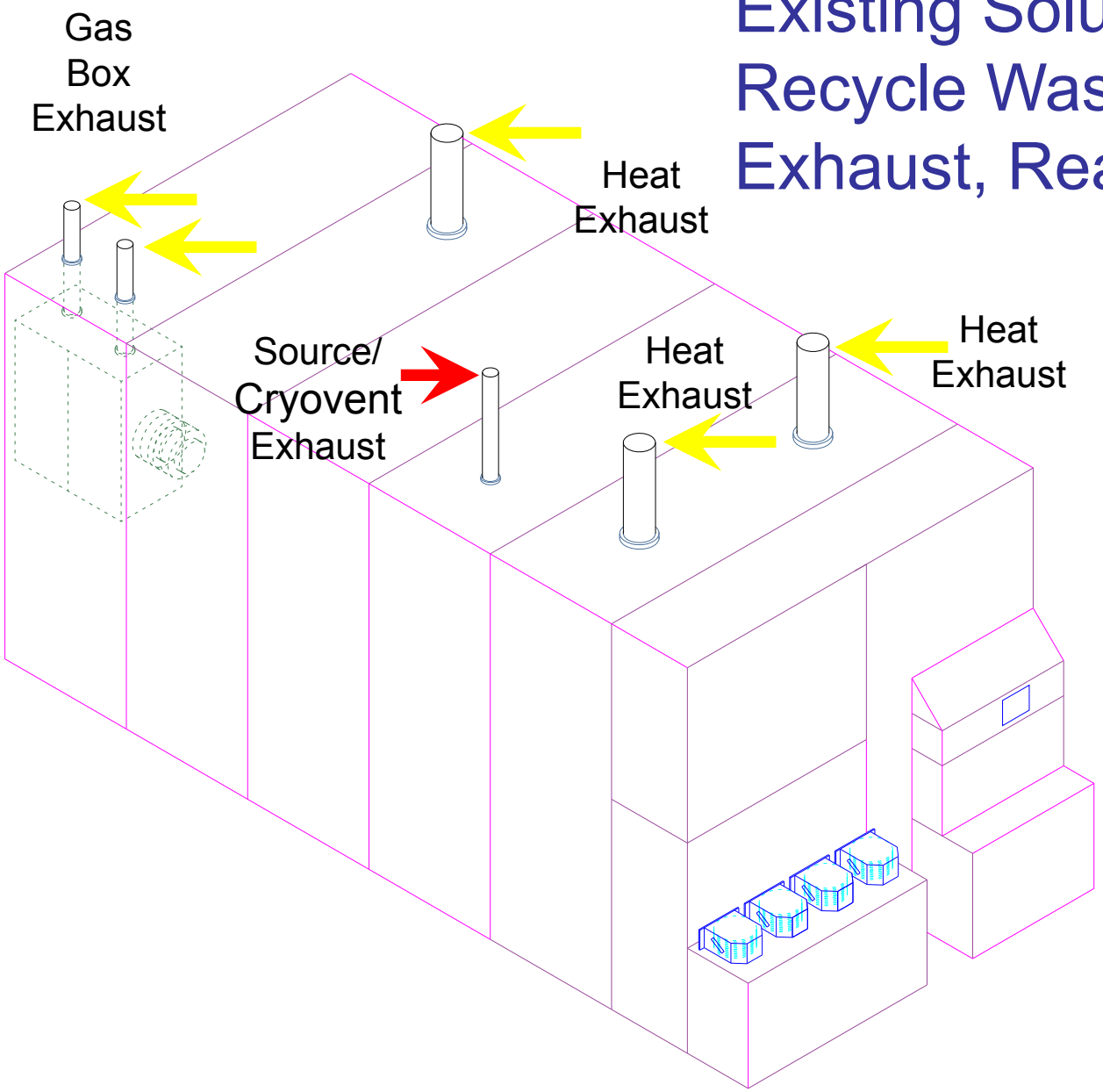


Existing Solution – Recycle Waste Heat Exhaust



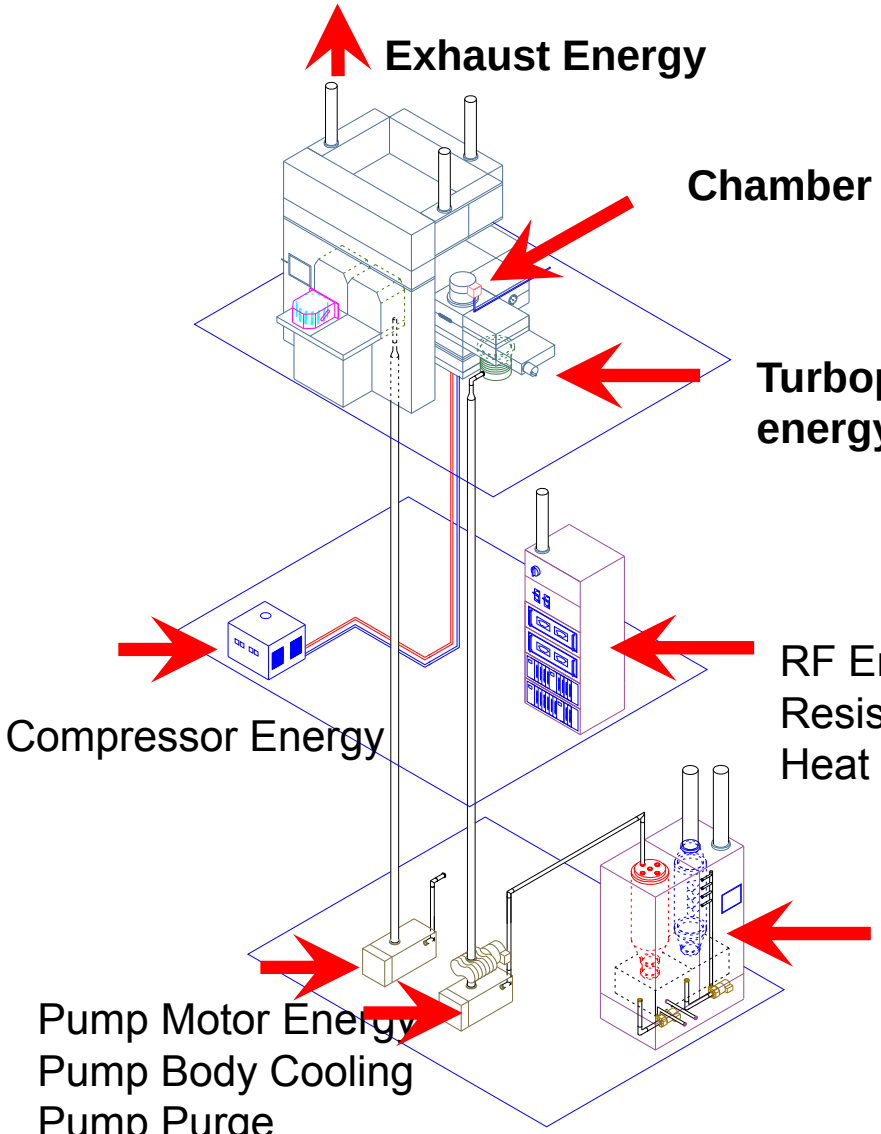
Another reactive solution

Existing Solution – Recycle Waste Heat Exhaust, Reactive



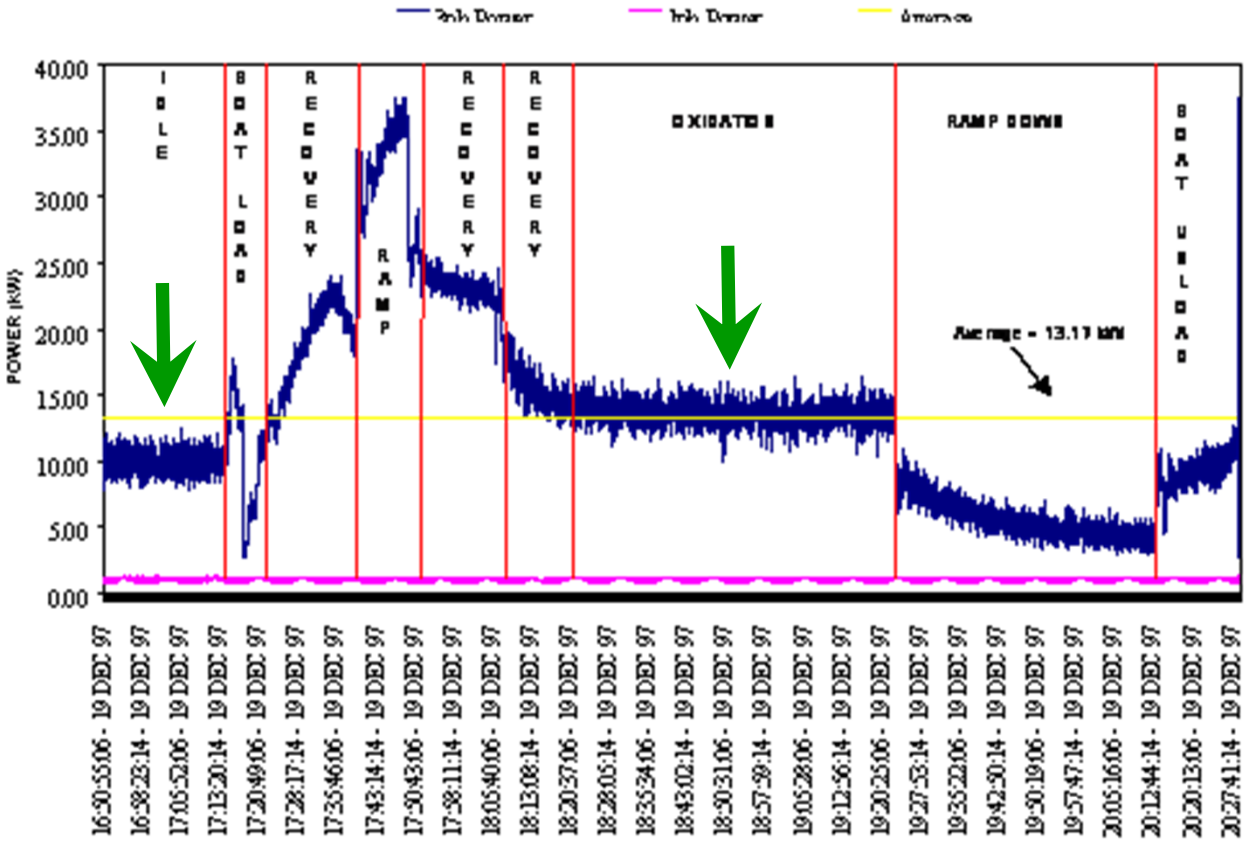
- Recycle, no issues
- Recycle with caution, use engineering controls (i.e. online gas detection inside duct)
- Not recommended, do not recycle. Not suitable for heat exhaust system.

Needs: CVD/Etch



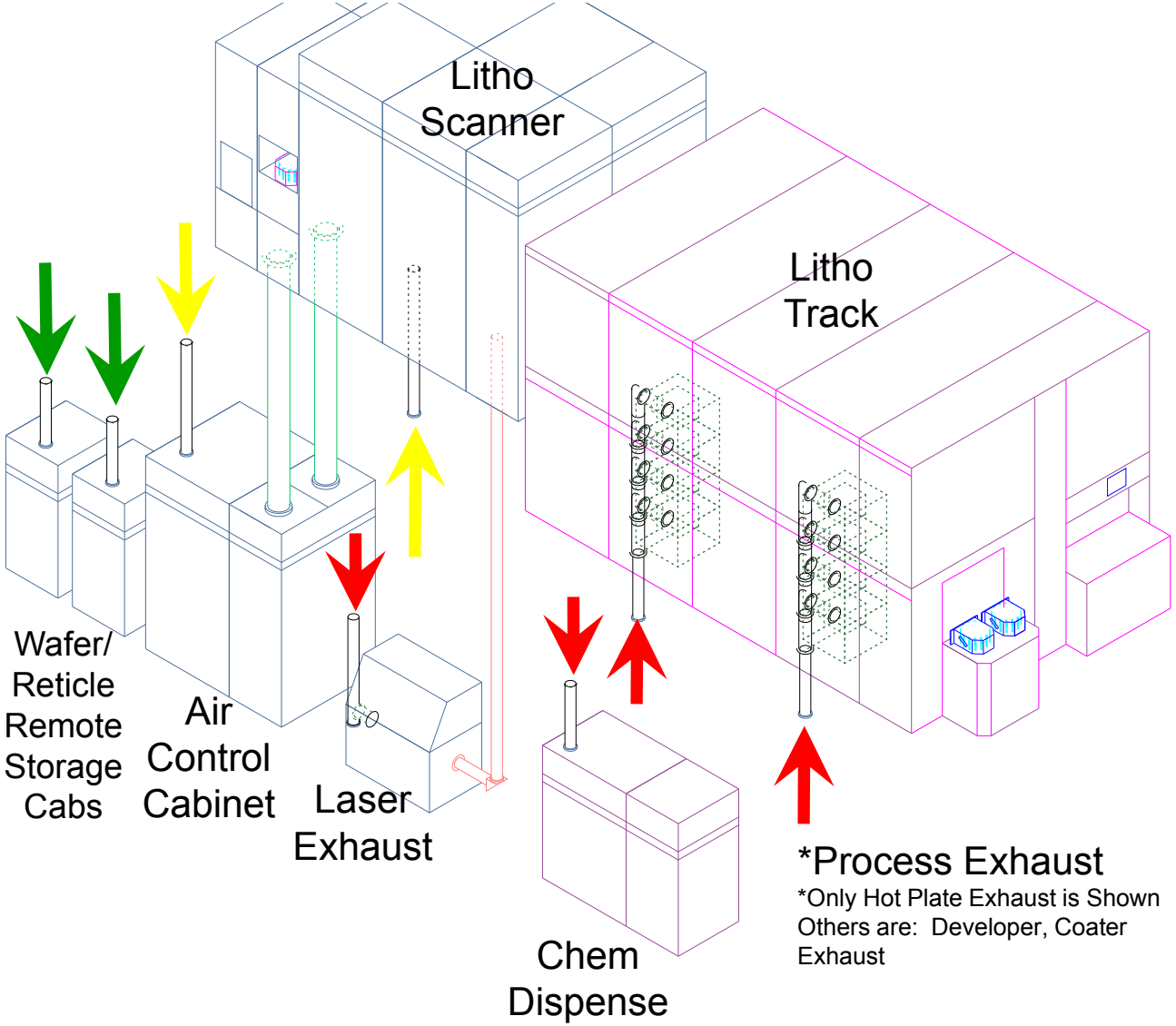
CVD/Etch: More stable films, lowered dependency on temperature. Enables reduced chamber heating in process and idle conditions.

Needs: Diffusion



Diffusion:

- More stable materials: poly, nitride and oxide.
- Current furnace idle temperatures are 600^{o}C with ramping to 1200^{o}C in process.
- Upon cooling, nitride and poly processes have particulate issues.
- However, oxide shows stability down to ambient temperatures.
- A particle characterization study is needed with a goal of minimizing idle temperatures.



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Litho need – reduce organic waste from baking out solvents

Needs For Energy Reduction by Process

- General: Materials that are more robust and less sensitive to temperature and humidity without compromising process performance.
- Litho:
  - Improved resist stability.
  - Current drivers are tradeoffs with line etch rough (LER), sensitivity and resolution which will not change.
  - We only need an improvement from current make up air requirement of 0.1^{o} Δ per hour for 193nm litho.
- Diffusion:
  - More stable materials: poly, nitride and oxide.
  - Current furnace idle temperatures are 600^{o}C with ramping to 1200^{o}C in process.
  - Upon cooling, nitride and poly processes have particulate issues.
  - However, oxide shows stability down to ambient temperatures.
  - A particle characterization study is needed with a goal of minimizing idle temperatures.

Needs For Energy Reduction by Process

- General: Materials that are more robust and less sensitive to temperature and humidity without compromising process performance.
- Implant:
  - Continue work on high dose implant resist stripping.
  - Significant impact on heating requirements, chemical and water consumption.
  - Minimize waste heat and exhaust in both processing and idle conditions.
- Wets/Post CMP:
  - Encouraged by progress of in-situ monitoring.
  - Need to prove in high volume manufacturing.
  - This will be the first step towards reducing chemical and water consumption without impacting the process.
  - 60-80^{o} C temperature setpoints may not ever move due to reduced cycle times.
- CVD/Etch: More stable films, lowered dependency on temperature. Enables reduced chamber heating in process and idle conditions.