Opportunities for optimizing vacuum and abatement systems for Extreme Ultra Violet Lithography

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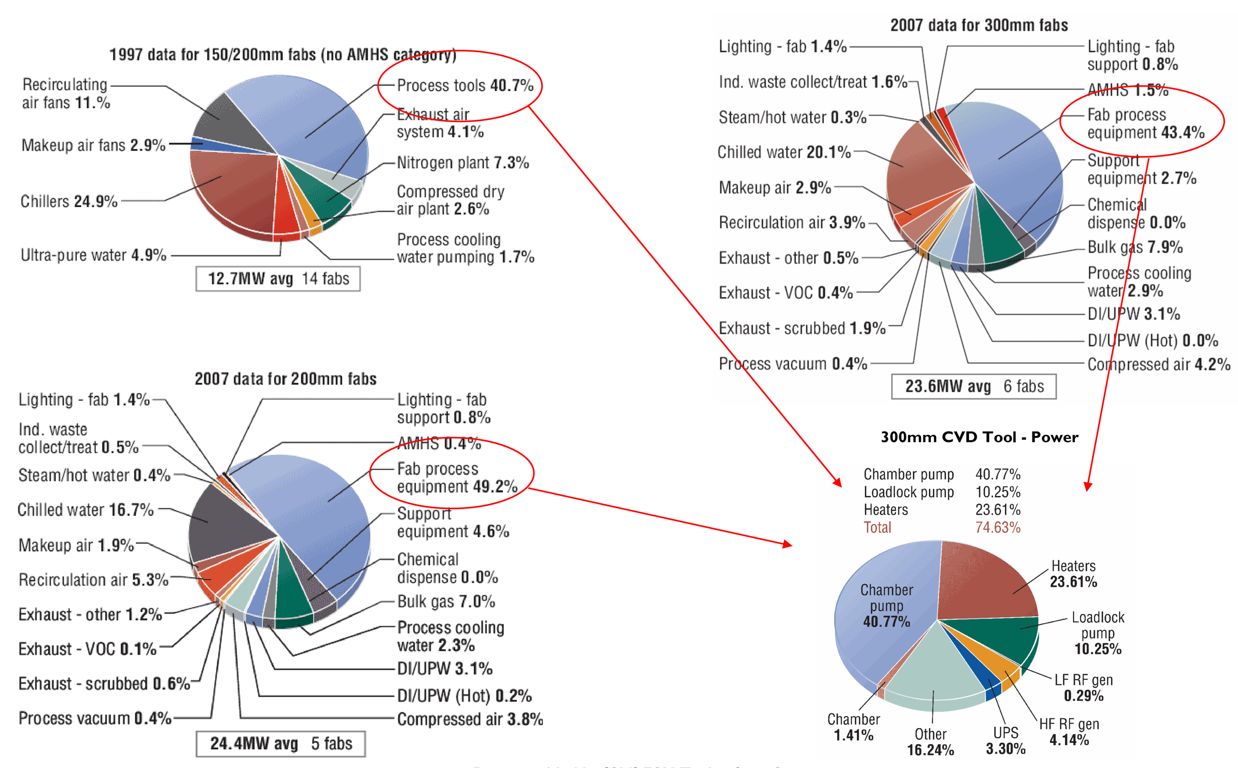
- **Compared to conventional methods, Extreme Ultraviolet Lithography requires the addition of a vacuum subsystem. Edwards has collaborated for over 10 years with the EUV Lithography community during the development of EUV equipment which has necessarily accommodated a range of process gases and operating conditions. As the process moves from pilot production towards volume manufacture the process conditions are becoming more tightly defined, which allows the system specification to be optimized for this duty. Edwards recognizes that cost of ownership is still a key challenge for commercialization of EUV Lithography. Optimizing the vacuum subsystem will help to reduce the utility consumption and energy costs associated with this process.**

- The cost of ownership of semiconductor manufacturing equipment is typically addressed in terms of raw utility consumption but in semiconductor lithography especially tool uptime is a critical parameter to be considered in the cost of ownership model.

Energy Consumption → Cost of Ownership

- Research carried out by the ISMI ESH centre has shown that the energy consumed by a typical semiconductor fab has doubled over a 10 year period (1997-2007).

- Within the fab the process equipment is identified as accounting for 40 to 50% of the total power consumption and approximately 70% of the process equipment energy is typically used by the vacuum equipment.



Data provided by ISMI ESH Technology Center

- EUV lithography brings an additional element of vacuum equipment to the semiconductor fab, consequently the proportion of energy attributed to process equipment is likely to increase further.

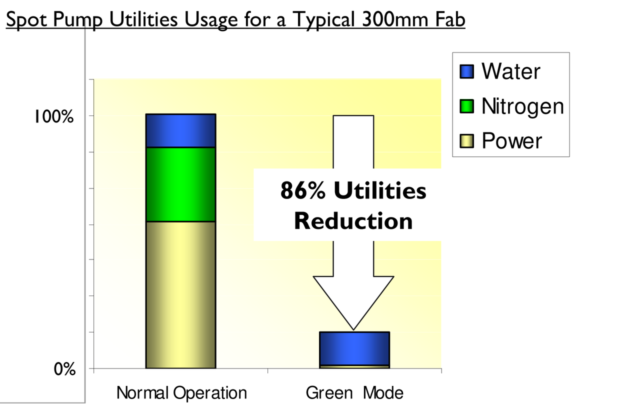
- With this trend it is increasingly important to focus on more efficient ways of operating both tool and facility equipment.

→ **GREEN** mode operation

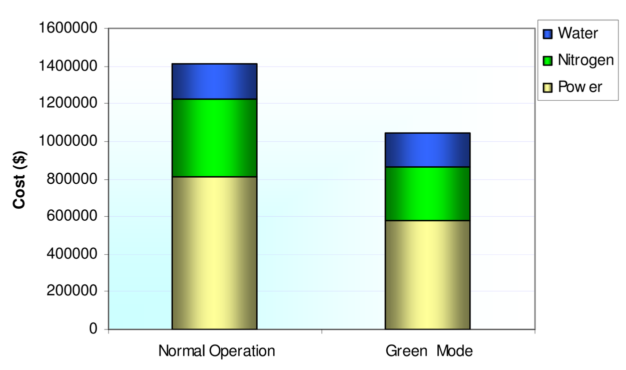
Mode 3 pump stopped	Mode 2 pump slowed	Mode 1 P & T maintained
Maximum utility savings attained by slowing pumps to 0Hz. Pump control system remains active.	DP and MB kept turning at low speed.	Pump inlet pressure and temperature are maintained for turbo pump backing and/or where there may be condensable by-products.

- Up to 86% pump utility savings are possible fab-wide
  - Power **up to 97% saving** by reducing pump speed
  - Nitrogen **up to 100% saving** by turning off/reducing N_2
  - Water **up to 3% saving** by reducing cooling water flow

Spot Pump Utilities Usage for a Typical 300mm Fab



Model based on a 300mm logic fab (80k wpm) containing 874 pumps. Mix of iXL/iGX/iXH pumps. Assumes all pumps are in Green Mode 3.



300mm logic fab (80k wpm) containing 874 dry pumps. 70% of time running normal operation and 30% in Green Mode 3. Utility cost assumptions: Power $0.07/kWh; Nitrogen $0.00006/liter; Water $0.0002 l/liter.

- Green mode enables **$363,000 (26%) annual utilities saving** for a typical 300mm Semicon fab
  - Pumps in Green Mode for 30% of time

- Equivalent to **1,778 tonnes reduction in CO2 emissions**

- Edwards is part of the ISMI ESH Technology Centre which has been established to further address the energy and resource conservation needs of the semiconductor industry.

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Tool Uptime → Cost of Ownership

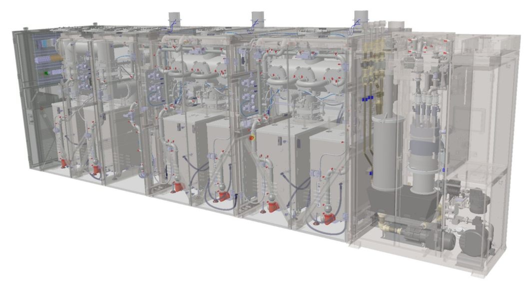
- Optimisation of vacuum subsystems through intelligent design and control can enable greater tool uptime, thereby improving overall cost of ownership.

Integration

- Integration of vacuum and abatement equipment into a full process tool subsystem with intelligent control can enable:
  - > 50% reduced installation time
  - > 50% reduced installation costs
  - > 40% foot print reduction
  - > 20% energy savings

→ **energy reduction** through integration

- Integrated system design by application or total tool requirements
  - With or without abatement
  - Process specific
  - Modularity for flexibility
  - Enhanced control and data package



→ **optimized operation**

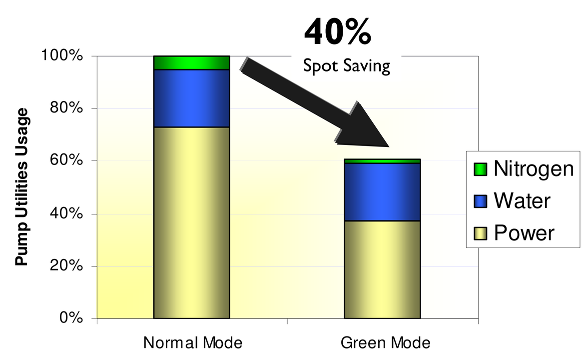
Control

- Intelligent system control can play an important role in activating **GREEN** mode functionality e.g.:

- via communication from the Manufacturing Execution System (MES)
  - Based on Fab-wide wafer movements
  - Maximize saving between batch runs
  - Exit from Green Mode may be timed to wafer arrival
  - Connection – GEM / SECS II to Fabworks Eco-Link

- via direct communication from tool
  - Closely coupled to tool activity
  - Green Mode can take advantage of short tool idle periods
  - Visibility of pump status at the tool
  - Green Mode timing able to vary with different process recipes
  - Currently in use at major production facilities
    - Major Flat Panel Display customer in Taiwan – 250 pumps
    - Major Crystal Pulling customer in Europe – 20 pumps

- Green Mode 2 implemented on **250 pumps** installed on Gen 8 55K PECVD Tools
  - Each tool has 5 process chambers, 1 load lock chamber, 1 transfer chamber
- Green Mode 2 is tool-activated via pump MicroTIMs



- **In future semiconductor fabs uptime and reliability of subfab equipment, such as vacuum and abatement equipment, becomes highly critical with the increasing capital and operational costs for IC manufacturing tools.**

- **Optimization of vacuum and abatement equipment through intelligent design and use of smart operating modes can lead to substantial overall fab cost savings.**

- **With the introduction of smart modes it is not only possible to make utility cost savings, also tool uptime can be guaranteed without the loss of vacuum performance at given times such as during service.**

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