

SEMI Technical Education Program
SEMI Standards / ISMI Present SEMI S23 -
Energy Conservation
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ISMI S23 Supplier Application Guide and Total Equivalent Energy Tool

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The cover image for the ISMI S23 Supplier Application Guide and Total Equivalent Energy Tool features a background of a brushed metal surface with a circular pattern. The text "INTERNATIONAL SEMATECH" is positioned above the large, bold, white letters "ISMI", which are set against a blue background with horizontal white stripes. Below "ISMI" is the text "MANUFACTURING INITIATIVE" in white, bold, uppercase letters on a black background.

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ISMI
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ISMI S23 Application Guide overview

- Part 1: S23 Application Guide
 - Aid in the application of SEMI S23-0705 “*Guide for Conservation of Energy, Utilities, and Material Used by Semiconductor Manufacturing Equipment*”
 - Provide guidance in the selection and use of utility measurement instruments
 - Provide recommendations for resource use reduction
- Part 2: Total Equivalent Energy (TEE) Tool instructions
 - Converts various semiconductor manufacturing equipment utility consumption rates into *equivalent annual electrical energy usage*
 - TEE Tool exports S23 data to Microsoft Excel™
- Application Guide is published on SEMATECH public website or available on request:
 - www.sematech.org: **TTID # 06094783B-ENG**

ISMI S23 Application Guide Section I: **Selecting and Using Measurement Instruments to Conserve Resources**

- Intent: Facilitate SEMI S23 application by providing supplemental information
 1. Measurement practices
 - Recommended power, flow (gas, exhaust, liquid), pressure, temperature measurement methods
 - Comparison of instrument types: cost, ease, required accuracy
 2. Conservation practices
 - Understanding and applying recommendations
 - By major facility system
 - By parameter affecting system efficiency



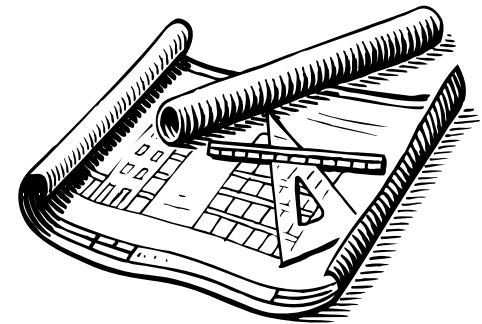
Introduction – TEE Tool

- TEE Tool is a powerful Excel™ based application
- Converts tool utility consumption to KWh/year
 - Comprehensive analysis of *direct* and *indirect* energy consumption
 - Differentiate between “processing” & “idle”
- Provides a standard report format for S23
 - Export as an Excel™ spreadsheet
 - Data can be used in other applications



TEE Tool Benefits for Equipment and Device Manufacturers

- Rapid calculation of Total Equivalent Energy
- Ability to compare up to 4 tools, graphically
- Aids in developing energy reduction improvement roadmaps
- Determine impact of utility flow changes on operating cost
- Assess operational cost impacts of component selections



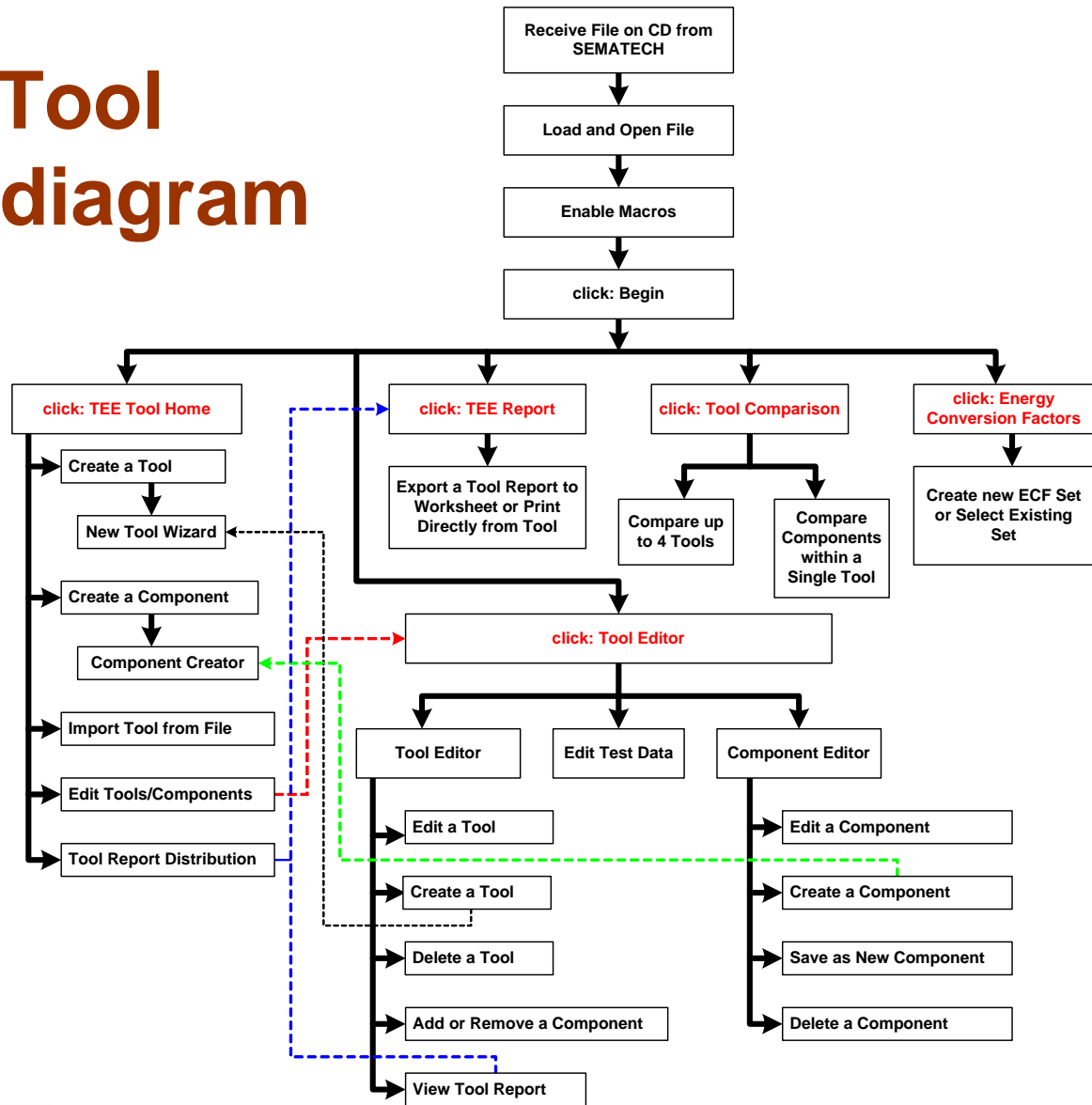
TEE Tool – Key Features

- Default SEMI S23 Energy Conversion factors (ECFs)
 - Added Hot UPW, High Pressure CDA
 - Ability to create and assess alternate ECFs
- Calculates heat added to the cleanroom as “heat burden”
- S23 “processing” & “idle” tool modes
- Process Tool = summation of its Components
 - User defines Components and Tools
- Results can be graphed or exported to Excel™



TEE Tool enables users to easily assess and report total operational cost impacts

TEE Tool flow diagram



What You Need to Get Started

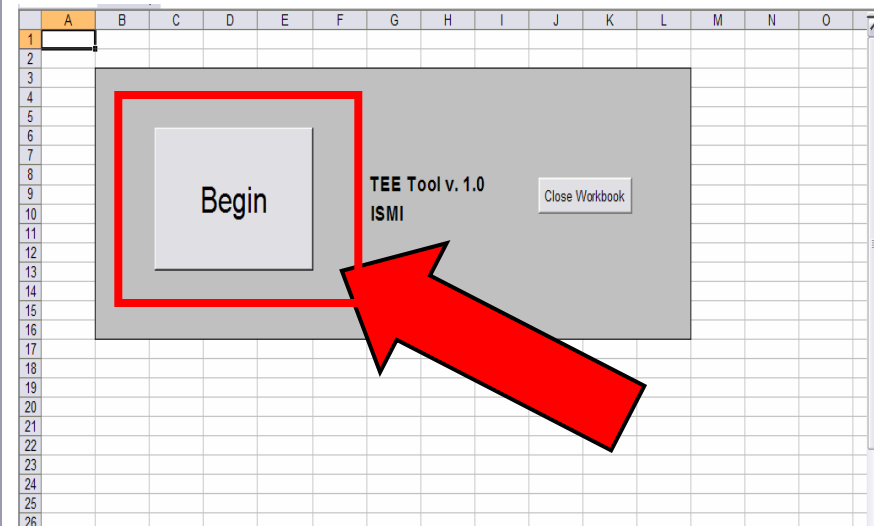
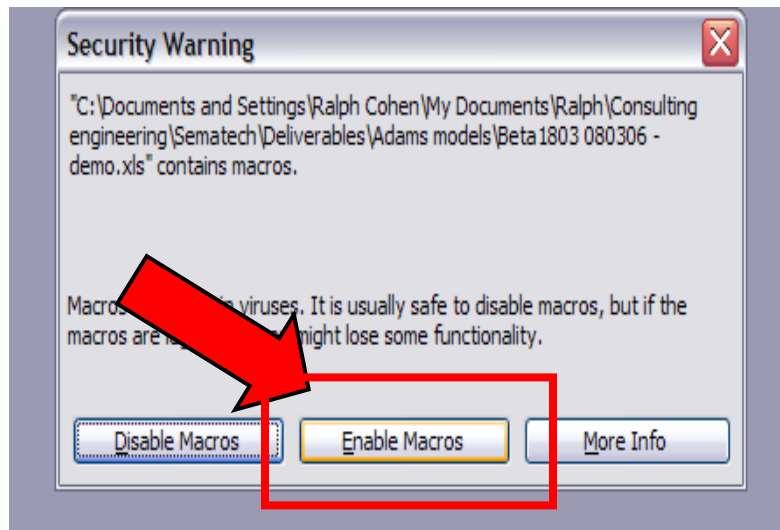
- Obtain TEE software CD or download from ISMI public website (available August 1, 2007)
- Verify computer meets software requirements
 - Microsoft Windows 2000, X/P Home or Professional
 - Microsoft Excel™: 2003 or later
 - TEE Tool might be unstable with earlier versions
 - Known issues with Excel 2000



Opening & Saving the TEE Tool file

- Click on **Enable Macros**
- Click on **Begin** button on opening screen

Hint: Save to new file name after opening 1st time



From TEE Tool Home

- Create/Edit tools or components
- View/Export tool report

1: TEE Tool Home | 2: Tool Editor | 3: TEE Report | 4: Tool Comparison | 5: Energy Conversion Factors

ISMI Total Equivalent Energy Tool

My Tools

- Recharge Distributor
- Collater Cap

Select an Option

Step 1: Tool Creation

- Create a New Tool
- Create a New Component
- Import a Tool from a Spreadsheet

Step 2: Tool Editor

- Edit Tools
- Edit Components

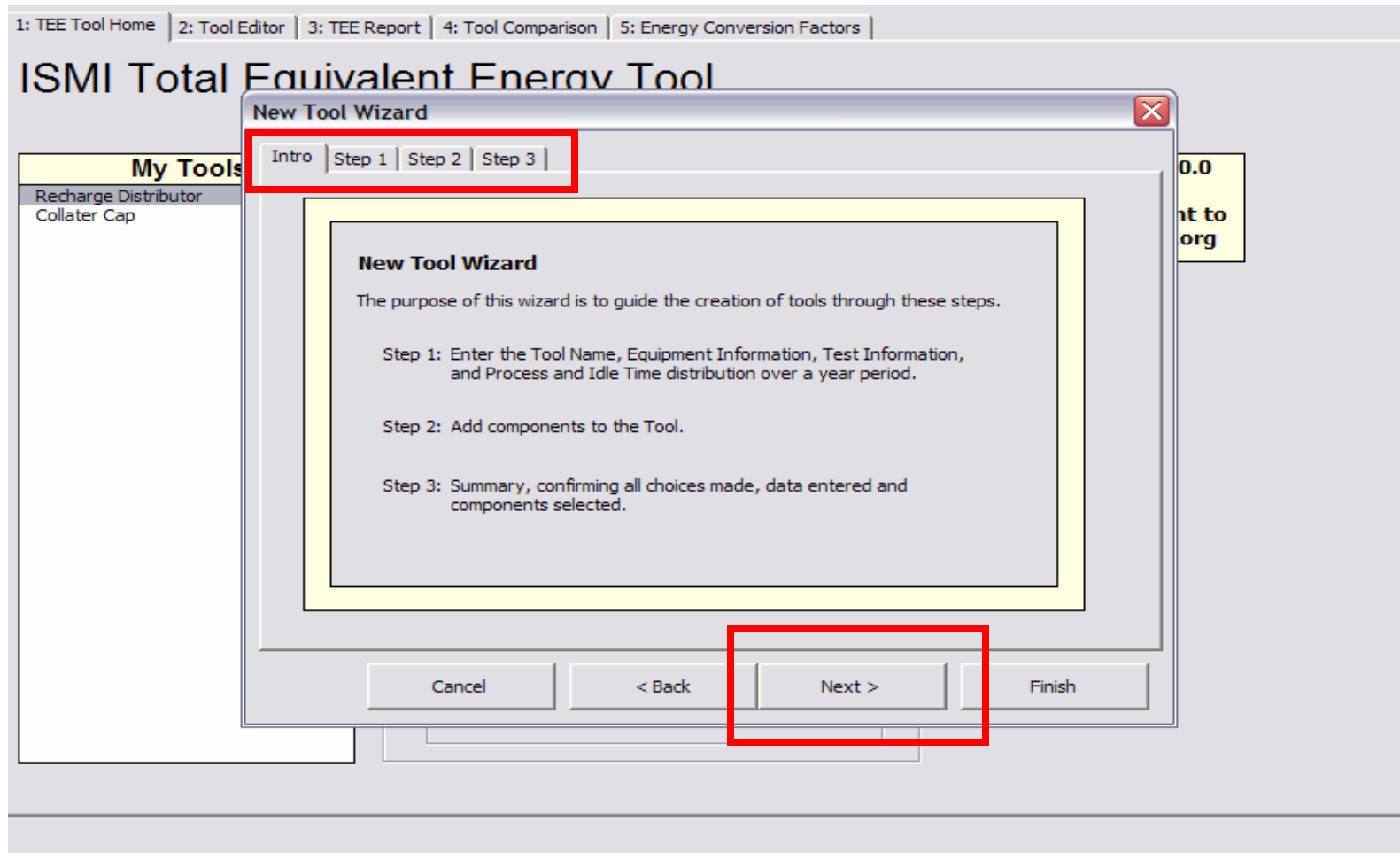
Step 3: Tool Report Distribution

- View TEE Report
- Export a Tool Report to a Spreadsheet
- Export a Tool Set

TEE Tool Version 1.0.0
6/18/2007
Feedback can be sent to
TEETool@sematech.org

Clicking on **Create a New Tool** opens “New Tool Wizard”

- Progress through steps 1-4 by clicking Next



Create a New Tool: Step 2

- Tool Information Page
- Fill in required fields (required)

The screenshot shows the 'New Tool Wizard' window in the TEE User Tool application. The wizard is on Step 2, 'Tool Information Page'. The page contains several sections of input fields:

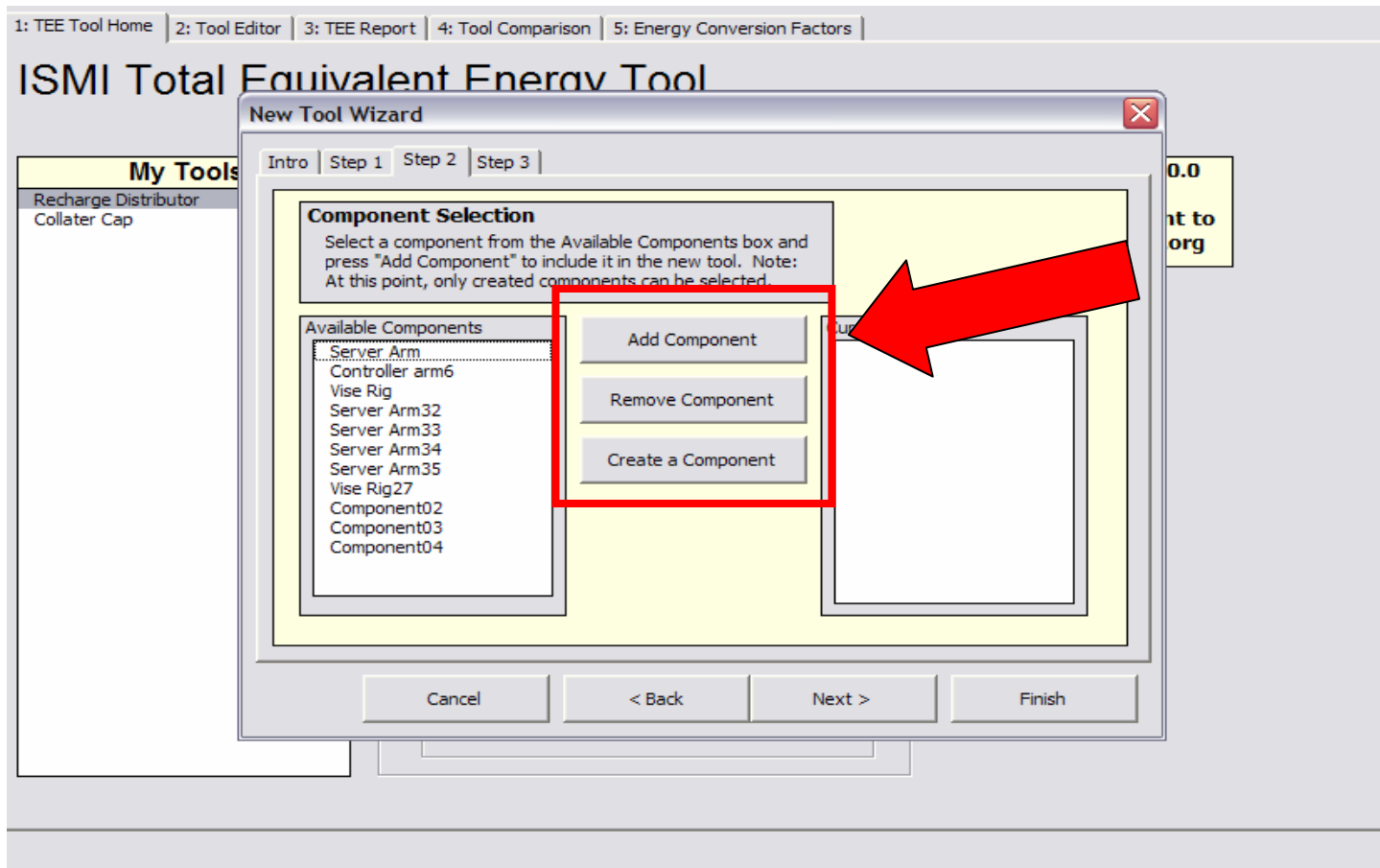
- Equipment Information:** This section is highlighted with a red box. It contains four fields: '*Tool Name' (filled with 'ZBT 5000'), 'Model Number', 'Serial Number', and 'Manufacturer'. The asterisk indicates that the Tool Name is a required field.
- Test Information:** This section contains four fields: 'Date(mm/dd/yyyy)', 'Test Location', 'Equipment Operator', and 'Test Inspector'.
- Time Distribution % (Hours/Year):** This section contains three fields: '*Process Time' (filled with '86'), '*Idle Time' (filled with '12'), and '*Maintenance' (filled with '2'). The asterisks indicate that Process Time, Idle Time, and Maintenance are required fields.
- Contact Information:** This section contains three fields: 'Company Name', 'Contact Person', and 'Phone Number'.

At the bottom of the wizard, there are four buttons: 'Cancel', '< Back', 'Next >', and 'Finish'. The 'Next >' button is highlighted, indicating the user is ready to proceed to the next step.

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Create a New Tool: Step 3 - Component Selection

- Click on Add / Remove / Create



Click on **Component Creator**

- Use pull down menus for units
- Enter data (gaseous in “standard conditions”)

TEE User Tool

1: TEE Tool Home | 2: Tool Editor | 3: TEE Report | 4: Tool Comparison | 5: Energy Conversion Factors

Tool Editor | Component Editor

| Utility | Flow | | | Pressure | | Temperature | | | |
|-----------------------|-------------------------------------|------|------|------------------|------|-------------|--------|------|----|
| | Processing | Idle | Unit | Utility Pressure | Unit | Inlet/Main | Outlet | Unit | |
| Exhaust | <input checked="" type="checkbox"/> | 1000 | 500 | cfm | 250 | Pa | 72 | 75 | °F |
| Nitrogen | <input checked="" type="checkbox"/> | 20 | 10 | cfm | 100 | psi | 72 | | °F |
| Vacuum | <input checked="" type="checkbox"/> | 10 | 5 | cfm | 25 | Inch Hg | | | |
| Dry Air | <input checked="" type="checkbox"/> | 20 | 10 | cfm | 100 | psi | | | |
| High Pressure Dry Air | <input checked="" type="checkbox"/> | 20 | 10 | cfm | 150 | psi | | | |

Process Cooling Water

| Utility | Flow | | | Pressure | | | Temperature | | | |
|-----------|-------------------------------------|------|------|-------------|--------|------|-------------|--------|------|----|
| | Processing | Idle | Unit | Supply/Main | Return | Unit | Inlet/Main | Outlet | Unit | |
| 20C - 25C | <input type="checkbox"/> | 10 | 5 | gpm | 70 | 30 | psi | 55 | 60 | °F |
| 32C - 37C | <input checked="" type="checkbox"/> | 0 | 0 | gpm | 0 | 0 | psi | 0 | 0 | °C |

Ultra Pure Water

| Utility | Flow | | | Temperature | | |
|----------|-------------------------------------|------|------|-------------|------|----|
| | Processing | Idle | Unit | Inlet/Main | Unit | |
| Standard | <input checked="" type="checkbox"/> | 5 | 2.5 | gpm | 20 | °C |
| Hot | <input checked="" type="checkbox"/> | 7.5 | 3.75 | gpm | 80 | °C |

Finished with Component?

Save Changes

Save as a New Component

Hint: Save Changes to an existing component, or Save Changes to a New Component

Click on **Tool Editor** tab

- Create / Delete Tool
- Edit Test Data (“Save Data” after change)
- View Tool Report or Tool / Component Energy

The screenshot shows the 'EE User Tool' interface. At the top, there are navigation tabs: '1: TEE Tool Home', '2: Tool Editor', '3: TEE Report', '4: Tool Comparison', and '5: Energy Conversion Factors'. Below this, there are sub-tabs for 'Tool Editor' and 'Component Editor'. The main content area is titled 'Test Data Snapshot: Recharge Distributor'. It features a sidebar on the left with 'My Tools' and a list of tools including 'Recharge Distributor' and 'Collater Cap'. The main area contains several tables and buttons. A red box highlights the 'Edit Test Data' and 'Save Data' buttons. Below these are three main sections: 'Equipment Information', 'Test Information', and 'Recharge Distributor Component Data'. The 'Equipment Information' table lists details like Tool ID, Model Number, and Manufacturer. The 'Test Information' table lists Date, Test Location, and Equipment Operator. The 'Recharge Distributor Component Data' section includes 'Energy Totals: Current Tool' and 'Energy Use by Component: Selected Component' tables. Arrows point from the '435338' value in the 'Energy Totals' table to the '435338' value in the 'Energy Use by Component' table.

| Tool ID | Recharge Distributor |
|---------------|----------------------|
| Model Number | XJ-728 |
| Serial Number | 1234567 |
| Manufacturer | Veltron Labs |

| Date | 3/1/2007 |
|--------------------|-----------------|
| Test Location | Austin |
| Equipment Operator | David Jones |
| Test Inspector | Reginald Dwight |

| Company Name | Plinktronics |
|-----------------|--------------|
| Contact Name | James Mason |
| Contact Phone # | 512-555-1234 |

| Process Time | 75 |
|--------------|----|
| Idle Time | 20 |
| Other | 5 |

| Energy | Value |
|---------------|--------|
| Exhaust | 6966 |
| Vacuum | 130602 |
| Nitrogen | 435338 |
| Dry Air | 255978 |
| High Pressure | 204726 |

| Component | Value |
|---------------|--------|
| Exhaust | 4138 |
| Vacuum | 65301 |
| Nitrogen | 238133 |
| Dry Air | 115956 |
| High Pressure | 204726 |

Data in units of “KWh/year”

Click on **Component Editor** tab

- Create / Delete Component
- Edit Component information and Data (and “Save Changes”)
- Change the data (and “Save as a New Component”)

1: TEE Tool Home | 2: Tool Editor | 3: TEE Report | 4: Tool Comparison | 5: Energy Conversion Factors

Tool Editor | **Component Editor**

My Components

| |
|---|
| A |
|---|

Component Information

| | | |
|-----------------|----------|--|
| Component ID | A | |
| Mean Real Power | kWh/year | |
| Process | 100 | |
| Idle | 50 | |

Note: All measurements should be taken using normal temperature and pressure.

Heat Sources (other heat sources, excluding power)

| | | |
|--------------------------|-----------|--------|
| Average Heat Input/Hr | 3413 | btu/hr |
| Heat Sources Description | H2 burner | |

Create New Component Delete Current Component

Save Changes Save as a New Component

Gases / Nitrogen

| Utility | | Flow | | | Pressure | | Temperature | | |
|-----------------------|-------------------------------------|------------|------|------|------------------|---------|-------------|--------|------|
| | | Processing | Idle | Unit | Utility Pressure | Unit | Inlet/Main | Outlet | Unit |
| Exhaust | <input checked="" type="checkbox"/> | 1000 | 500 | cfm | 250 | Pa | 72 | 75 | °F |
| Nitrogen | <input checked="" type="checkbox"/> | 20 | 10 | cfm | 100 | psi | 72 | | °F |
| Vacuum | <input checked="" type="checkbox"/> | 10 | 5 | cfm | 25 | Inch Hg | | | |
| Dry Air | <input checked="" type="checkbox"/> | 20 | 10 | cfm | 100 | psi | | | |
| High Pressure Dry Air | <input checked="" type="checkbox"/> | 20 | 10 | cfm | 150 | psi | | | |

- Click on **Energy Conversion Factors (ECF)** tab
- Click pull down tab for alternate ECF's
 - OR create alternate ECF's from ECF Worksheet (see next slide)

1: TEE Tool Home | 2: Tool Editor | 3: TEE Report | 4: Tool Comparison | 5: Energy Conversion Factors

ECF Set Name: S23 Standard

ECF Conversions

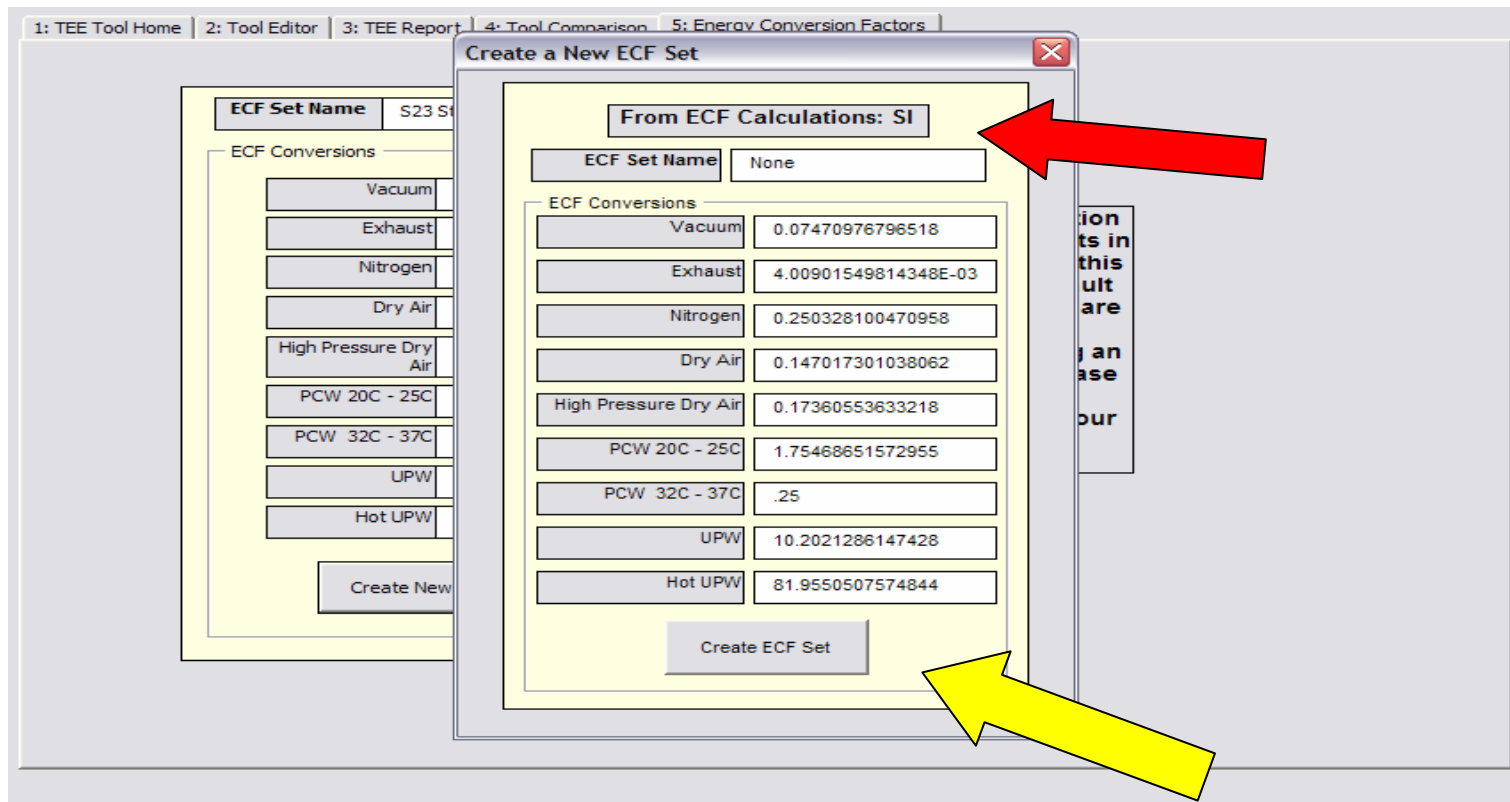
| | |
|-----------------------|-------|
| Vacuum | 0.075 |
| Exhaust | 0.004 |
| Nitrogen | 0.25 |
| Dry Air | 0.147 |
| High Pressure Dry Air | 0.175 |
| PCW 20C - 25C | 1.78 |
| PCW 32C - 37C | 0.25 |
| UPW | 10.2 |
| Hot UPW | 92.2 |

Create New ECF Set

WARNING: Please use caution when defining your ECF sets in the worksheets outside of this tool. ECF Worksheets default to the S23 standard. If you are not sure of the correct calculations for developing an independent standard, please use the S23 conversion factors when developing your Energy Reports.

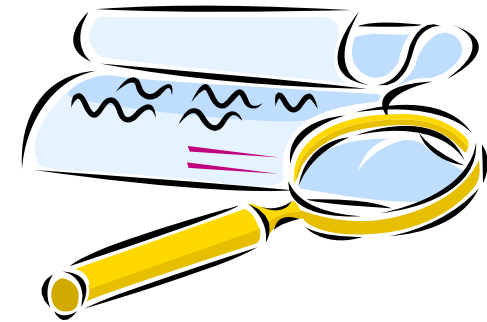
Click on **Create New ECF set** (see prior slide)

- User defined values may be inputted and saved with a unique name
- May use ECF calculation worksheets (SI or IPS) after closing TEE Tool



Obtaining TEE Tool Results

- Review: To create a TEE Report
 - Configure a specific tool's components
 - Enter component operating parameters / data
 - Associate tool components with the specific tool
 - Select the ECF (Energy Conversion Factor) set
- Click on **TEE Report** tab
 - Select process tool from Tool ID pulldown menu
 - Export to Worksheet or Print Report
 - ***S23 Equipment Energy Report!***



Generating a TEE Report (Click on **Tool ID** pulldown menu; select tool)

- Print report from screen
- Export to an Excel™ Workbook / Save as a new file

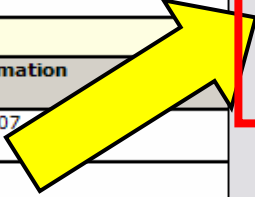
1: TEE Tool Home | 2: Tool Editor | 3: TEE Report | 4: Tool Comparison | 5: Energy Conversion Factors

| Total Equivalent Energy Report | | Tool ID |
|--------------------------------|----------------------|-------------------------------|
| Company Name: Plinktronics | | Recharge Distributor |
| ECF Set Used: S23 Standard | | Contact Person: James Mason |
| | | Contact Phone #: 512-555-1234 |
| Equipment Specification | | |
| Equipment Information | | Test Information |
| ID | Recharge Distributor | Date |
| Model Number | XJ-728 | Test Location |
| Serial Number | 1234567 | Equipment Operator |
| Manufacturer | Veltron Labs | Test Inspector |
| | | Reginald Dwight |

Export to Worksheet

Print Report

Return Home



| Annual Summary | | | | | Time Distribution | Percentage(%) | (Hours/Year) |
|-----------------------|-----------------------|-----------------|-----------------------------|-------------------------|-------------------|---------------|--------------|
| Utility | Processing (kWh/Year) | Idle (kWh/Year) | Ratio (% of total kWh/Year) | Annual Total (kWh/Year) | | | |
| Vacuum | 117206 | 13396 | 8.0 | 130602 | Processing | 75 | 6570 |
| Exhaust | 6252 | 714 | 0.0 | 6966 | Idle | 20 | 1752 |
| Nitrogen | 390688 | 44650 | 26.0 | 435338 | Other | 5 | 438 |
| Dry Air | 229724 | 26254 | 15.0 | 255978 | | | |
| High Pressure Dry Air | 273481 | 31255 | 18.3 | 304736 | | | |
| PCW 20 - 25 C | 390451 | 76497 | 28.1 | 466948 | | | |
| PCW 32 - 37 C | 50362 | 11540 | 3.7 | 61902 | | | |
| UPW | 0 | 0 | 0.0 | 0 | | | |
| Hot UPW | 0 | 0 | 0.0 | 0 | | | |
| Mean Real Power | 150 | 50 | 0.0 | 200 | | | |
| | | Heat Burden | 0.0 | -1866522 | | | |

Note: Total Equivalent Energy excludes Heat Burden (the heat not removed by PCW or Exhaust)

Multi-Tool Report Exported to Worksheet

Click on **Export a Tool Set**

Click on **Add Tool**, then **Create Report** (page bottom)

1: TEE Tool Home | 2: Tool Editor | 3: TEE Report | 4: Tool Comparison | 5: Energy Conversion Factors

| | | | |
|---------------------------------------|--|------------------------|----------------|
| Total Equivalent Energy Report | | Tool ID | Litho Demo |
| Company Name: Wafer Services, | | Contact Person | Jill Smith |
| ECF Set Used: S23 Standard | | Contact Phone # | (512) 555-1212 |
| Equipment Specification | | | |

Export to Worksheet
Print Report
Export a Tool Set
Return Home

Multi-Tool Report Creation

Create a Multi-Tool Report
Select the Tools you want to insert into the Multi-Tool Worksheet, and click "Add Tool" to add them to your report.

Available Tools
Litho Demo
Etch Demo
Simple tool

Add Tool ->

My Tool Report
Litho Demo
Etch Demo

<- Remove Tool

Chart Preview

TEE Comparison

| Efficiency (%) | Hours/Year |
|----------------|------------|
| 80 | 7,008 |
| 15 | 1,314 |
| 5 | 438 |

Cancel **Create Report**

Example of Tool Data Exported to an Excel™ Worksheet Includes ALL Components Associated with the Tool

| TEE Comprehensive Report | | | | Tool ID: Litho Demo | | |
|---|-------------------------------------|-------------------------------------|------------------------------------|-----------------------------------|-------------------------------------|--------------------------------|
| ISMI | | | | ECFs Used: S23 Standard | | |
| Company: | | | | Company Name: Wafer Services, Inc | | |
| | | | | Number of Components: 3 | | |
| Equipment Specifications | | | | | | |
| Equipment Info | | | Test Info | | | |
| ID | Litho Demo | Date | 7/12/2007 | | | |
| Model # | 123456 | Location | Austin | | | |
| Serial # | 654321 | Operator | Reginald Dwight | | | |
| Manufacturer | Keene Industries | Inspector | Declan McManus | | | |
| Contact Information | | | Time | (Hours/Year) | Ratio(%) | |
| Name | Jill Smith | Process | 7,008 | 80 | | |
| Phone Number | (512) 555-1212 | Idle Time | 1,314 | 15 | | |
| | | | Other | 438 | 5 | |
| TEE Summary Report | | | | | | |
| Utility | Processing | Idle | Ratio (%) | Total(kWh) | | |
| Vacuum | 447 | 0 | 0.15 | 447 | | |
| Exhaust | 40,482 | 7,531 | 16.52 | 48,013 | | |
| Nitrogen | 8,930 | 0 | 3.07 | 8,930 | | |
| Dry Air | 3,501 | 0 | 1.20 | 3,501 | | |
| H.P. Dry Air | 31,255 | 5,860 | 12.75 | 37,115 | | |
| PCW 20°C-25°C | 45,331 | 3,718 | 16.85 | 49,049 | | |
| PCW 32°C-37°C | 0 | 0 | 0.00 | 0 | | |
| UPW | 8,578 | 0 | 2.35 | 8,578 | | |
| Hot UPW | 0 | 0 | 0.00 | 0 | | |
| Real Power | 126,144 | 3,138 | 46.50 | 135,342 | | |
| Heat Burden | | | 153.77 | 447,534 | | |
| Total | 264,668 | 26,367 | 100 | 231,035 | | |
| Annual Utility Energy Consumption by Component | | | | | | |
| Name Environmental Chamber | | | | | | |
| Utility | Tool Mode | Conversion Coefficient | Amount of use (M3/h) | Real power (kW/h) | Annual Energy (kWh/Year) | Subtotal (kWh/Year) |
| Vacuum | Processing | | 0.0 | 0.00 | 0 | |
| | Idle | 0.075 | 0.0 | 0.00 | 0 | 0 |
| Exhaust | Processing | | 843.5 | 3.40 | 23,813 | |
| | Idle | 0.004 | 843.5 | 3.40 | 4,465 | 28,278 |
| Nitrogen | Processing | | 0.0 | 0.00 | 0 | |
| | Idle | 0.250 | 0.0 | 0.00 | 0 | 0 |
| Dry Air | Processing | | 0.0 | 0.00 | 0 | |
| | Idle | 0.147 | 0.0 | 0.00 | 0 | 0 |
| High Pressure Dry Air | Processing | | 0.0 | 0.00 | 0 | |
| | Idle | 0.175 | 0.0 | 0.00 | 0 | 0 |
| PCW 20°C-25°C | Processing | | 1.4 | 2.43 | 17,464 | |
| | Idle | 1.780 | 1.4 | 2.43 | 3,274 | 20,738 |
| PCW 32°C-37°C | Processing | | 0.0 | 0.00 | 0 | |
| | Idle | 0.250 | 0.0 | 0.00 | 0 | 0 |
| UPW | Processing | | 0.0 | 0.00 | 0 | |
| | Idle | 10.200 | 0.0 | 0.00 | 0 | 0 |
| Hot UPW | Processing | | 0.0 | 0.00 | 0 | |
| | Idle | 32.200 | 0.0 | 0.00 | 0 | 0 |
| Heat Burden | Mean Supply Temperature (°C) | Mean Return Temperature (°C) | Temperature Difference (°C) | Annual Flow Amount (m³/Yr) | Coefficient | Removed Energy (kWh/Yr) |
| Exhaust Air | 23.00 | 25.00 | 3.000 | 7,063,585 | 0.000324 | 6,872 |
| PCW 20°C-25°C | 12.80 | 15.80 | 3.000 | 11,341 | 1.16 | 33,466 |
| PCW 32°C-37°C | 0.00 | 0.00 | 0.000 | 0 | 1.16 | 0 |
| Mean Real Power | Process/Idle | | 43,056 | 3,138 | Annual Heat Input to Spec | |
| er Heat Sources | | | 213,000 | | Estimated Annual Heat Burden | |
| | | | | | | 277,254 |
| | | | | | | 230,316 |

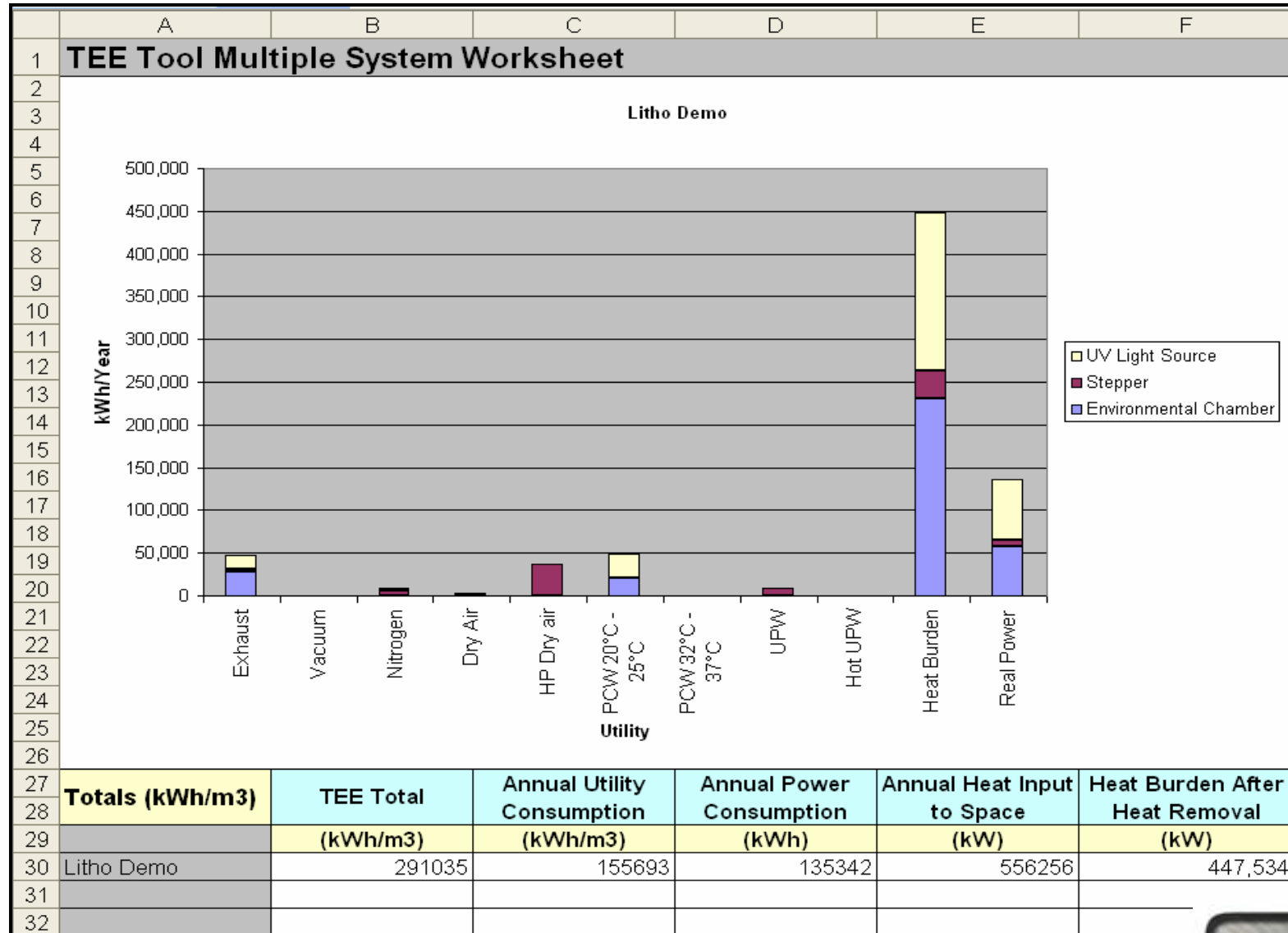
Use the exported spreadsheet file as S23 Tool Report!

Note:

Heat burden = Real power (-) heat removed by exhaust (-) heat removed by cooling water

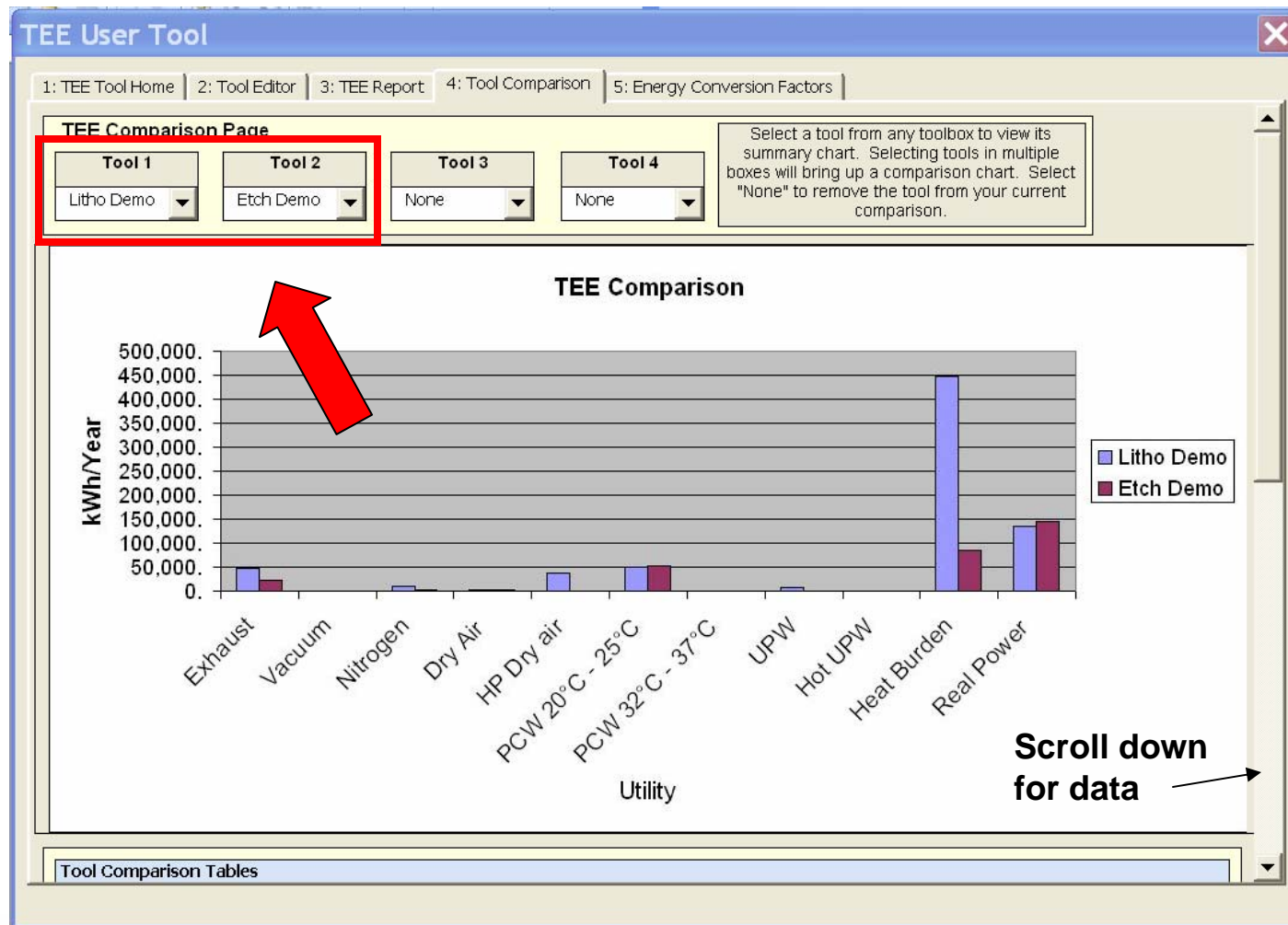
Heat burden must be removed by the cleanroom air conditioning system

Multi-Tool Cover Sheet for Tool Data Exported to Worksheet



The Tool Comparison tab

- Select up to 4 tools for comparison (pulldown menu)
- Bar graph appears; data populates below graph



Revision Control

- Report software problems or suggestions to teetool@sematech.org
 - Your feedback is important
- Check that current revision of software is being used
 - Download from ISMI public website
- The Application Guide TEE Tool will be revised as S23 is revised



Acknowledgements

- Application Guide development and STEP notes: Ralph Cohen, *RMOCC Consultancy*
- Software Development: John Mason, *Mason Computing*
- STEP support: Ian McLeod, Susan Turner – SEMI
- ISMI Supplier ESH Leadership Team

Questions? Comments?

Thank you for your participation!

ISMI SEMI S23 Total Equivalent Energy (TEE) Reporting Tool

- The ISMI SEMI S23 Total Equivalent Energy (TEE) Reporting Tool is a software utility created by ISMI, Inc. in order to assist the semiconductor supplier and user community in assessing and converting various semiconductor manufacturing equipment utility consumption rates into equivalent annual electrical energy usage (i.e., kilowatt hours per year) by multiplying specific utility consumption rates—m³/hour, liter/minute, etc.—by S23-defined per utility conversion factors (energy conversion factors or ECFs). The data gathered and calculations made are based on the SEMI S23 energy efficiency and road mapping guideline.
- The TEE Reporting Tool is included in this training package for your company's ("User") use. To install and/or use the ISMI SEMI S23 Total Equivalent Energy (TEE) Reporting Tool, User must accept and agree to adhere to ISMI's Software License Agreement in the README file included on the enclosed CD. Thereunder, User is licensed solely for Internal Use of the TEE Reporting Tool. Other restrictions apply. Title to the TEE Reporting Tool remains with ISMI and no title is transferred to User.
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