A Holistic Approach to Sustainable Semiconductor Test

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Teradyne

TestConX™
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TERADYNE

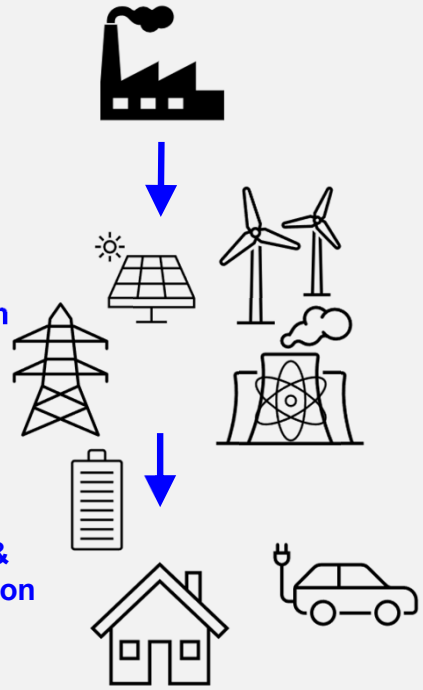
What is sustainability?

Emissions Reduction

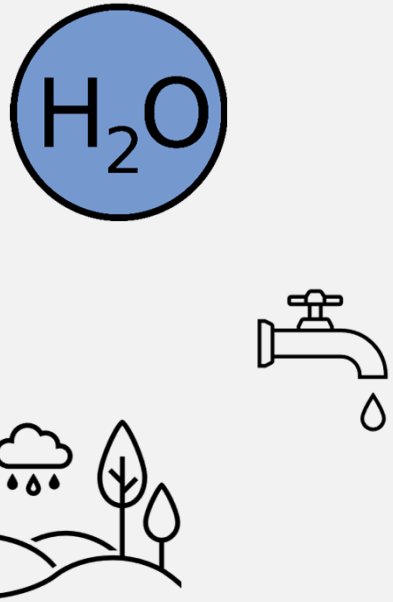
Carbon Intensive Energy

Low Carbon Energy

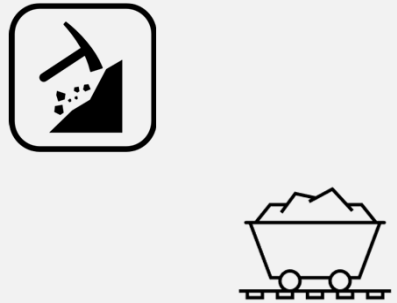
Efficiency & Electrification at Scale



Responsible Use of Water



Responsible Use of Materials



Product Life Cycle

Cradle-to-Grave

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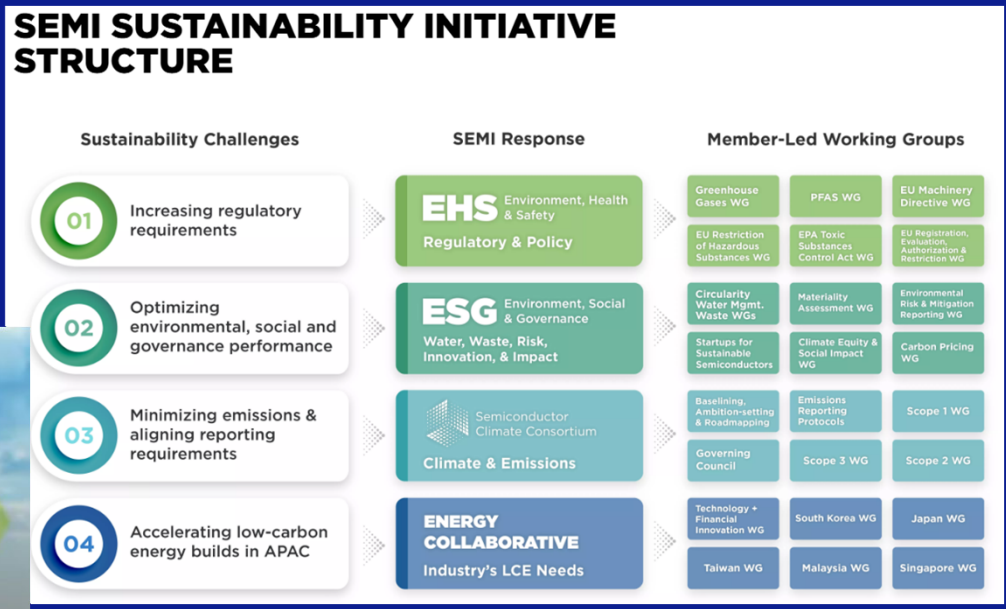
2025

SEMI and Industry Sustainability Initiatives



Sustainability Initiatives | Sustainable Programs at SEMI

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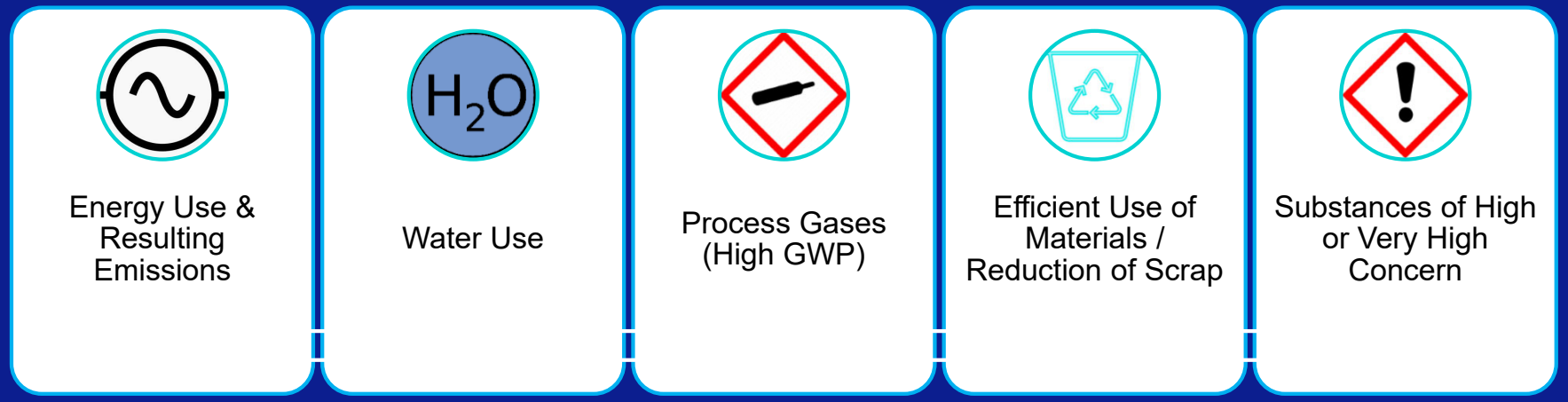
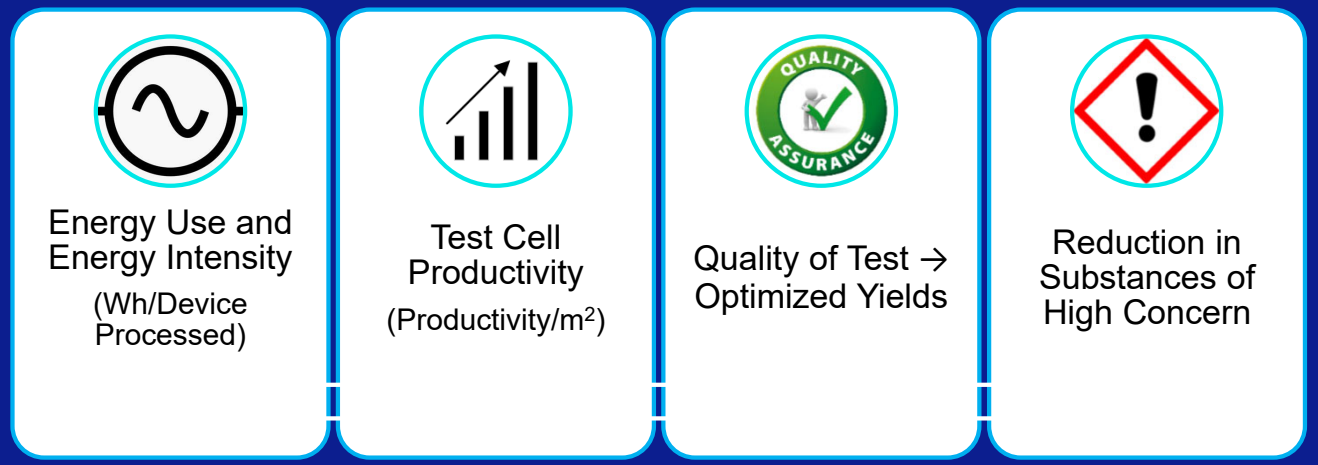
Semiconductor Sustainability:

What matters at the facility level?



Semiconductor Sustainability:

What matters for semiconductor test?



Semiconductor Sustainability:

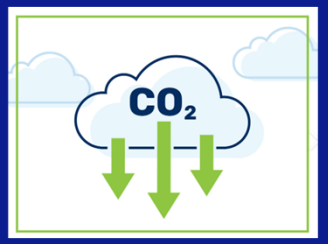
What matters for semiconductor test?

Energy Use and Energy Intensity
(Wh/Device Processed)

Test Cell Productivity
(Productivity/m^2)

Quality of Test → Optimized Yields

Reduction in Substances of High Concern



Sustainability can help protect the bottom line – an efficient and productive operation is a more sustainable operation.

Teradyne Product Sustainability Strategy

1. SYSTEM THROUGHPUT, PRODUCTIVITY AND EFFICIENCY
2. EQUIPMENT UTILIZATION: OPERATIONS AND OEE FACILITATORS
3. TEST CAPABILITY QUALITY AND FLEXIBILITY
4. INTELLIGENT FACTORY CAPABILITIES, AUTOMATION, ANALYTICS, AND INTEGRATED DATA
5. POWER AND ENERGY EFFICIENCY
6. INDUSTRY COLLABORATION

What are we learning?

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    - Customers
    - Industry bodies
    - Development partners
    - Value and Supply chain

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    - Customers
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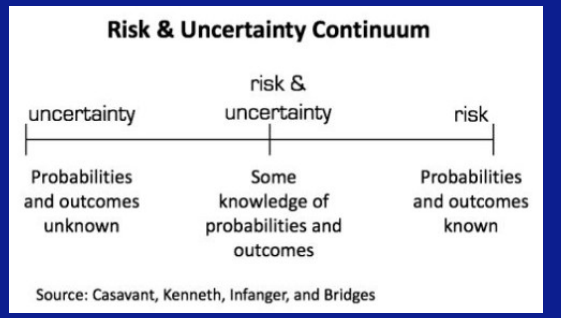
    - Development partners
    - Value and Supply chain
  - Higher tolerance for uncertainty and risk
    - Adapt to geo-political, regulatory, and industry volatility
    - Early adopter or fast follower?



Example 1: Throughput is a sustainability lever

Moving from prior generation of Semi equipment to current generation

We prioritize system throughput, productivity/m^2, and providing a more productive system.

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Analog Dominate Tester

- Typical 3:1 or 4:1 replacement ratios
- ≈ 48% to 72% Footprint Reductions
- ≈ 44% to 62% Annual Energy Reductions

Prior Generation Tester

Current Generation Tester

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Prior Generation Tester

Current Generation Tester

Digital Dominate Tester
- Typical 2:1 replacement
- ≈ 20% to 46% Footprint Reduction
- ≈ 49% Annual Energy Reductions

Prior Generation Tester

Current Generation Tester

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Efficient Operations → Sustainable Operations

↓ Floor space → ↑ Productivity/m²

↓ Energy Use → ↓ Energy Bills AND ↓ Emissions

↓ Emissions → ↓ Emissions Taxes AND ↓ RECs

Reduces Op Ex and protects the bottom line.

urrent Generation Tester

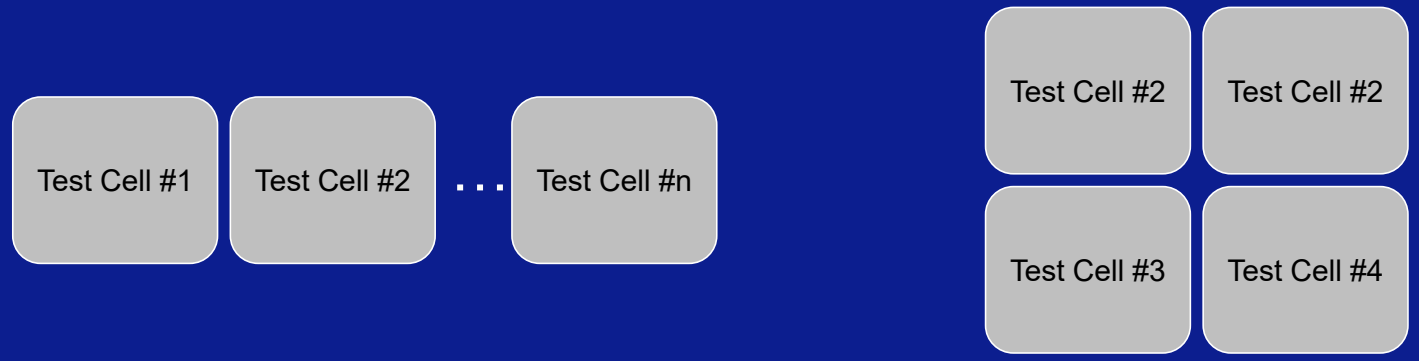
Prior Generation Tester

Current Generation Tester

Example 2: Optimizing Workflows and Floorspace

Floorspace and Workflow Optimization

- Increased test cell density → pull for n x m “test pods”
- Move to co-locate process steps/equipment types → streamline material handling
- Anticipate more *flexibility* required in setups → configurability, interface changes



Example 3: PFAS Use & Industry Impact

- **Thousands of PFAS chemicals [1] with many used by the Semiconductor industry. [2]**
  - Wafer Manufacturing/Processing
  - Device Packaging
  - Equipment components (e.g., Teflon/PTFE wire insulation; HV isolation components)
  - Cleaning agents and heat transfer fluids

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  - Device Packaging
  - Equipment components (e.g., Teflon/PTFE wire insulation; HV isolation components, elastomers)
  - Cleaning agents and heat transfer fluids
- **Introducing Non-PFAS Products**
  - Need to maintain system performance
  - Ensure system reliability and longevity
  - Provide customers with choice

[1] https://nasf.org/pfas/what-are-pfas/?gclid=Cj0KCQiAgK2qBhCHARIsAGACuzl3XUSBgjdcFirRCOv8jWIB0668WpyPPTnJiWFZodq6T-Ywt4Gv75AaAsRREALw_wcB
[2] https://www.semiconductors.org/wp-content/uploads/2023/04/Impact-of-a-Potential-PFAS-Restriction-on-the-Semiconductor-Sector-04_14_2023.pdf

Example 4: Addressing Energy Consumption

- **Industry is flowing aggressive targets for emissions/energy reductions to value chain**
  - Requires R&D investments
  - Deeper collaboration with customers and supply chain/vendors
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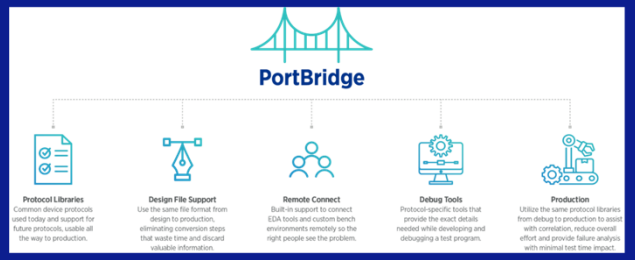
- **What makes this more difficult?**
  - Conflicting and evolving requirements
    - General trend toward higher digital channel density
    - Higher power devices
    - Strong pull for lower energy consumption
  - Need to maintain product reliability and robustness
  - **Cost sensitivity: customers want higher efficiency and more productive systems but appear unwilling to invest in depreciated equipment**

Example 5: Engineering & Manufacturing Productivity

Eng Productivity Tools

- Investing in modernized developer tools to reduce development time and TTM



Documentation & Training

- Offline tester emulation and software testing.
- Streamlining documentation interaction with an AI Assistant feature.

Manufacturing Efficiency

- Integrated and secure data → yield improvement
- Utility introduced for tester lower power modes → SEMI S23 “sleep”
- Continuous Improvements in productivity and opportunities for automation

Archimedes Analytics Solution

Conclusions

1. Sustainability can help control Op Ex and protect the bottom line; an efficient and productive operation is a more sustainable operation.
2. Semiconductor manufacturers and OSATs flowing sustainability requirements to the equipment suppliers.
3. Sustainability requires more than first-order thinking (i.e., it's more than energy and emissions).
4. Sustainability drives innovation → R&D and newer technologies → Business investment decisions.

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