

# *Sustainable Manufacturing Standards: Towards the Circular Economy*

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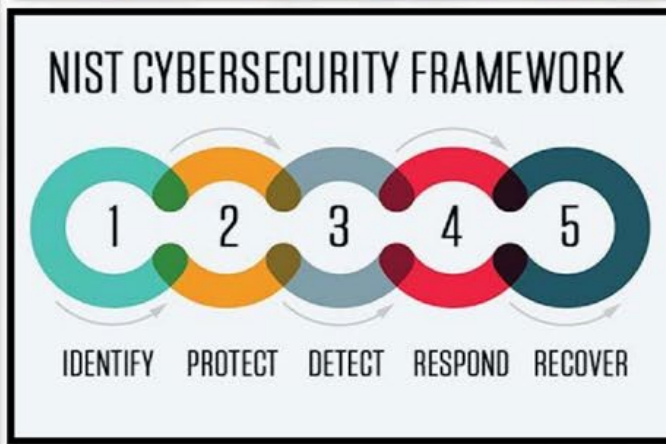
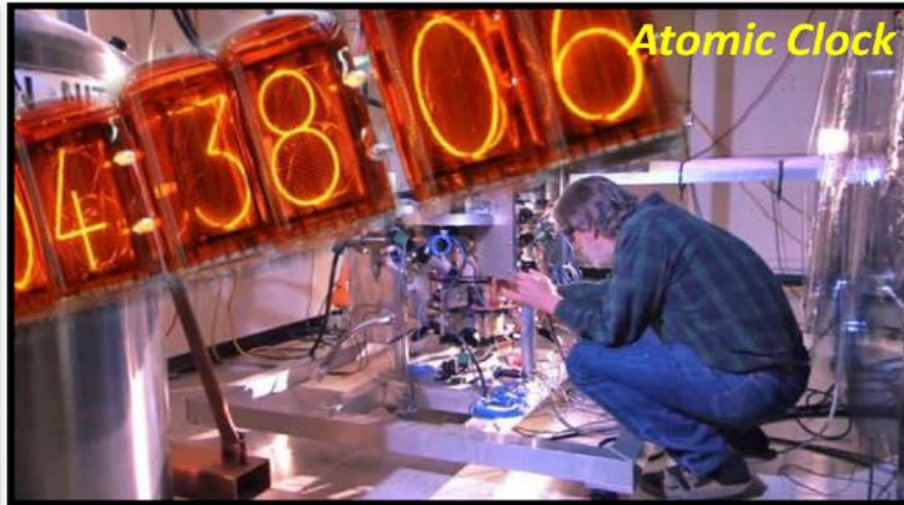
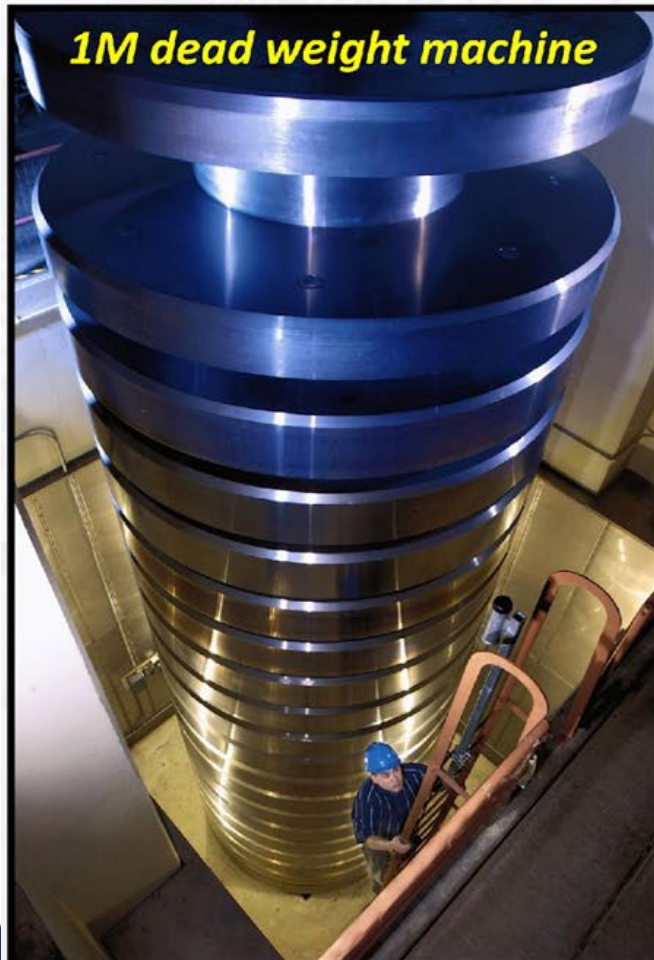
Presented at  
**NSF Workshop on Advance Manufacturing for Industrial Decarbonization**

August 2023



# NIST Mission

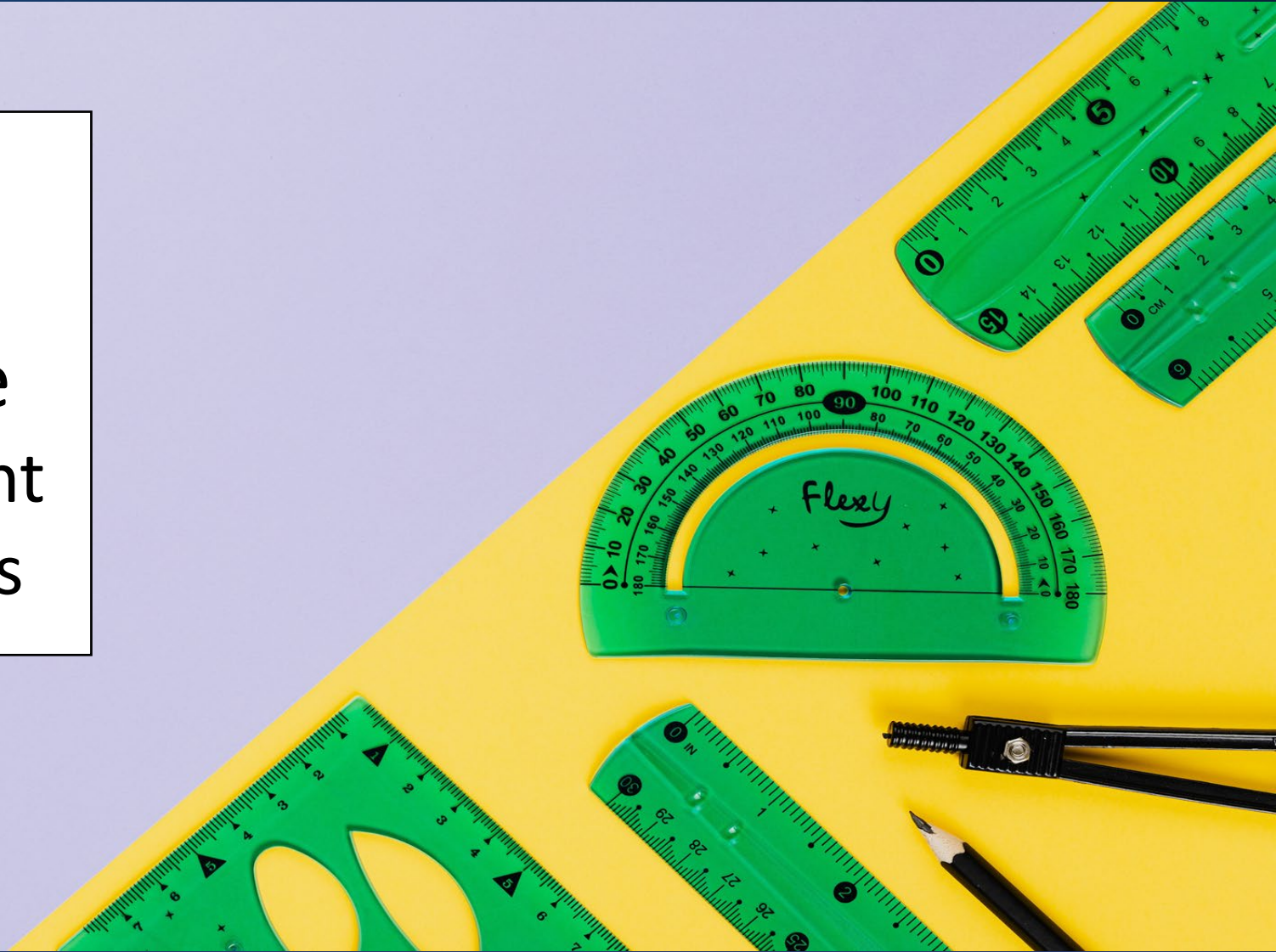
*promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve our quality of life*





# NIST is about Measurement Science

- What to measure
- How to measure
- How to communicate
  - Physical measurement
  - Meaning -> Indicators



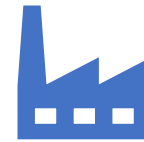
# Climate Crisis Rocks the World



**2021 Biden administration set goal to cut GHG Emissions by 52%**



**2020 Five largest Sustainability reporting NGOs combined forces towards uniform sustainability reporting standards.**



**2020 Manufacturing accounts for 29% of GHG emission in US**

24.2% in energy demand  
5.2% in direct processing



**Global push for more accountability includes supply chain focus.**

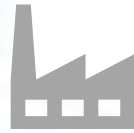
# Net-Zero Manufacturing Challenges

Transitioning to the Circular Net-Zero



## **Fuels and Energy Conversion**

Transition manufacturing practices to new Green Energy Technologies



## **Materials and Products**

Increase sustainability and efficiency in material and industrial production building on circular principles (reduce, reuse, recycling...).



## **Processes across the life cycle**

Improve processing at each life cycle stage:

- Advanced manufacturing
- Supply chain
- Recovery
- Carbon Capture, Storage, and Utilization (CCSU)



## **Systems Thinking**

Principles for circular product design

Sustainable Materials Management

Carbon accounting metrics



# Circular Economy is the next sustainability paradigm

## Response to problems imposed by

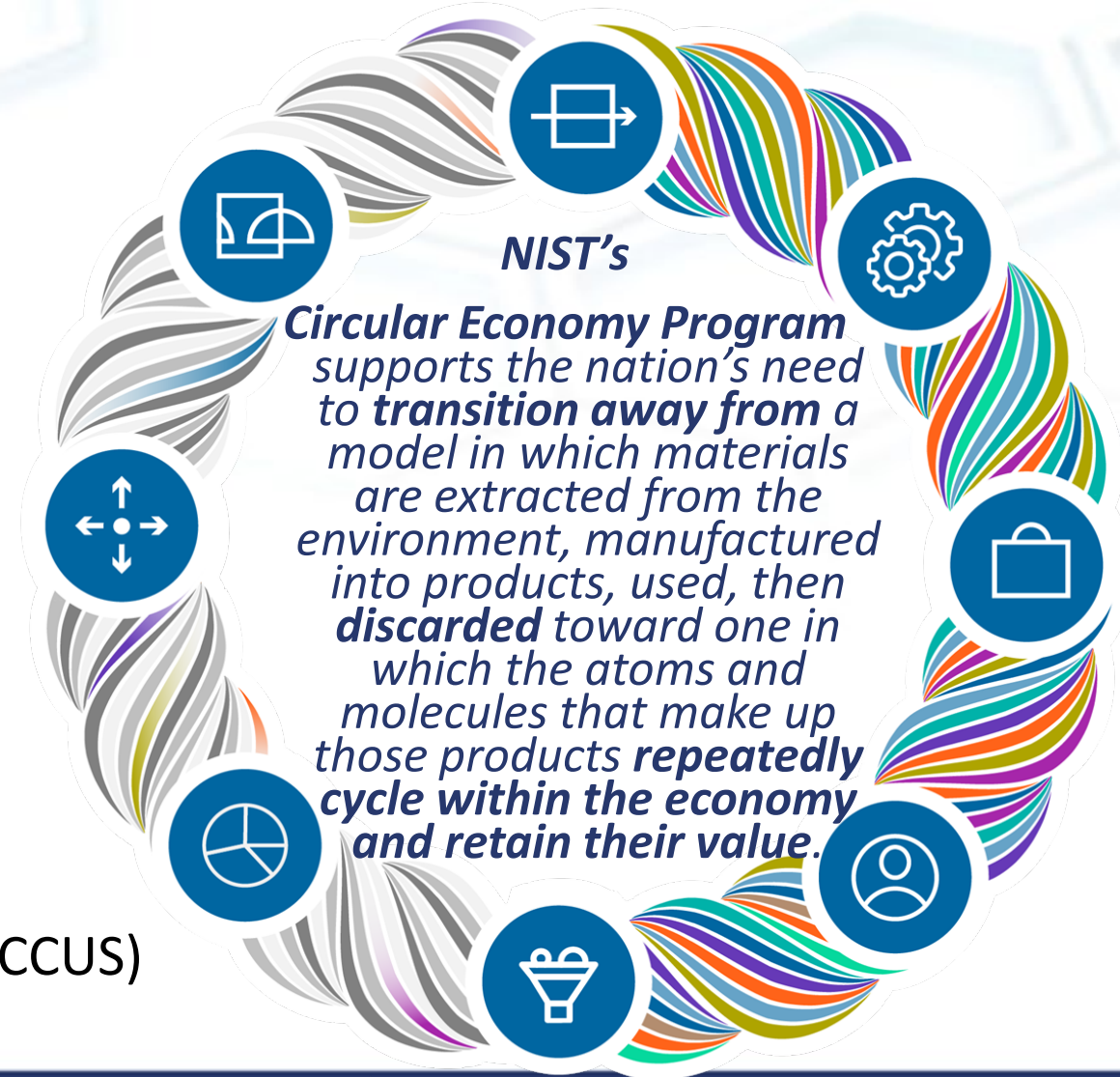
- limited global resources
- growing population (7.9B and growing)
- rising middle classes

## Economic model

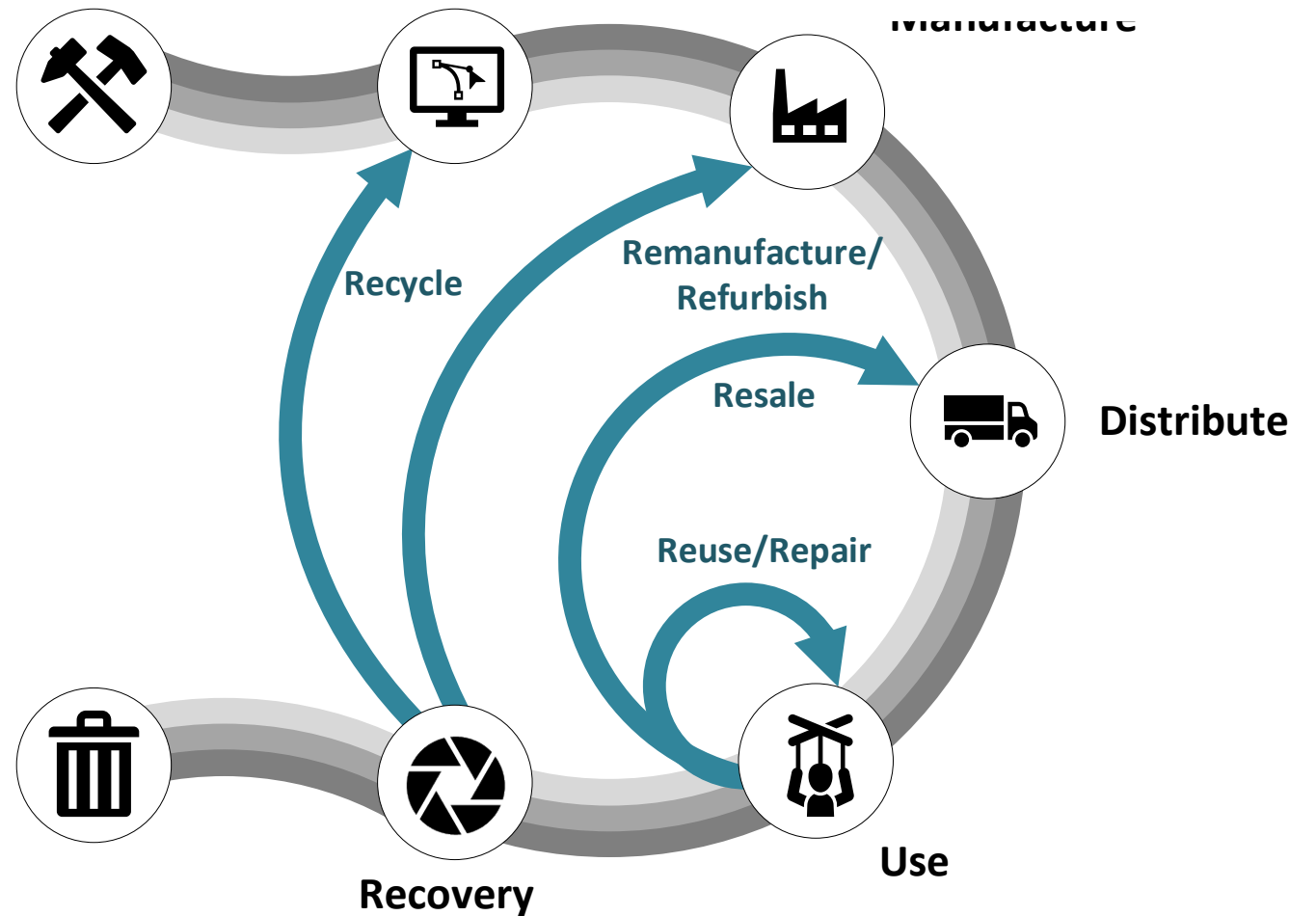
- All materials are recirculated into the economy
- Avoiding landfill or atmosphere

## Decarbonization Opportunities

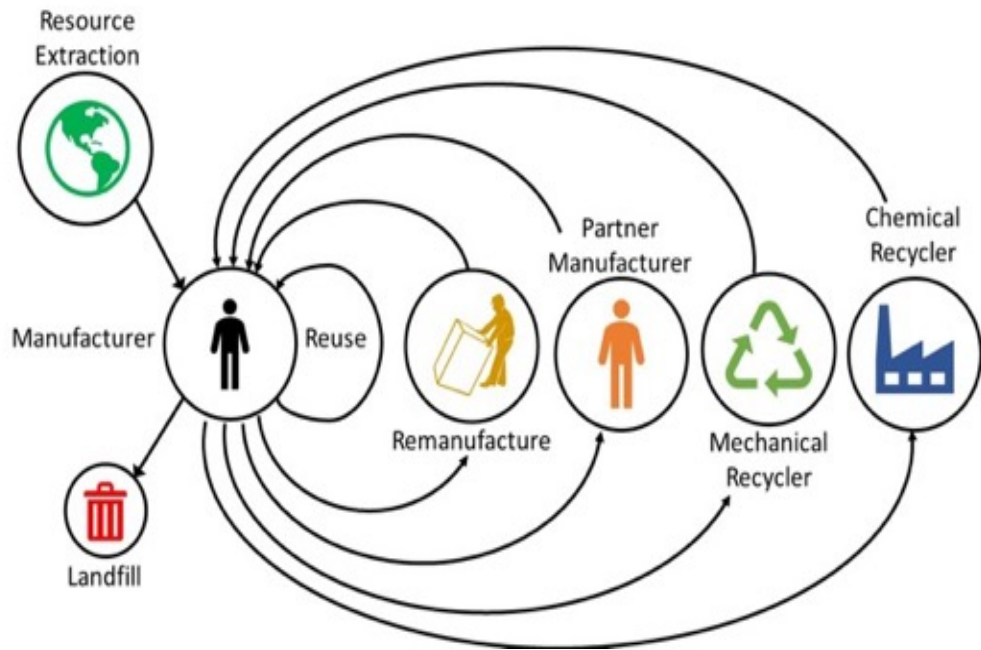
- Limit virgin material production
- Increase efficiencies thru Life cycle thinking
- Integrate carbon capture, utilization, and storage (CCUS)



# A Proposed Solution: Circular Economy



# Circular Economy needs new ways of measuring



## Sustainable Manufacturing

### Zero-waste operations

- Provide guidance for manufacturers to classify discarded materials
- Foster manufacturing partnerships to reuse material discards
- Identify most efficient recovery options

### Operational efficiency

- Establish baselines on process impacts
- Continuous improvement to reduce resource use and KPIs supporting sustainability
- Measure and reduce GHG contributions

## + Circular Economy

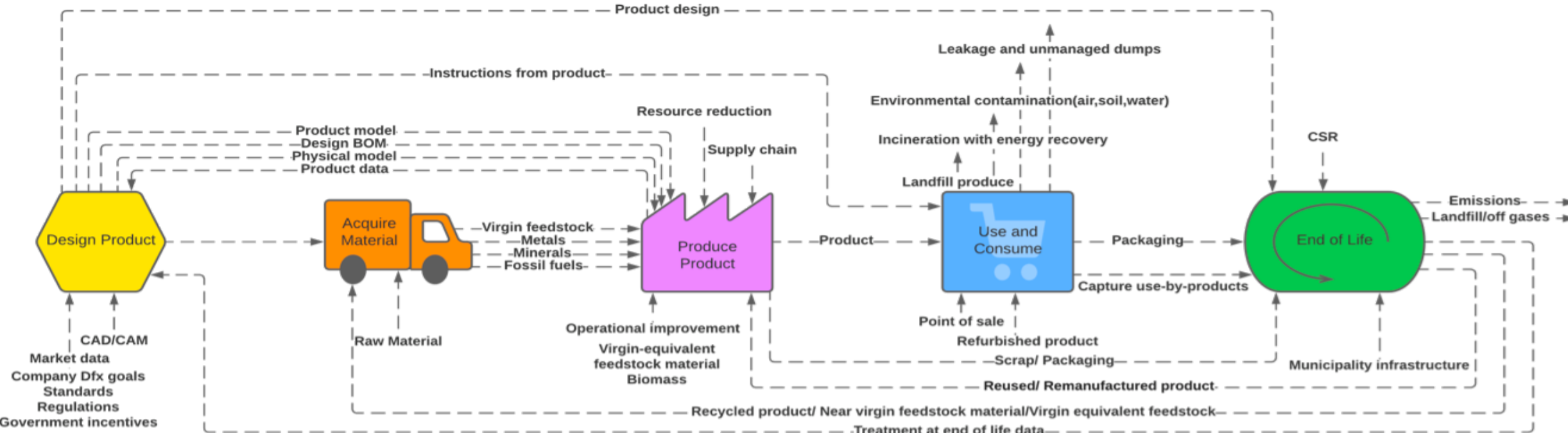
- Product design for circularity
- Smart Materials Management
- Managing system dynamics

## + Decarbonization

- Limit virgin material production
- Increase efficiencies thru Life cycle thinking
- Integrate carbon capture, utilization, and storage (CCUS)



# Standards Across the Manufacturing Lifecycle



EN IEC 62430:2019

EN 45559:2019

EN 45558:2019

ASTM E3096

ASTM E3012

ASTM E2986

EN 45553:2020

EN 45552:2020

GRI 306: Waste 2020

ISO 20140

EN 45554: 2020

BS8001

ISO/IEC GUIDE 41:2018

ISO 20400:2017

ASTM E2979

EN 45557:2020

EN 45556:2019

EN 45555:2019

ISO 14067:2018

GRI 305: Emissions 2016

ISO 14021:2016/AMD 1:2021

ISO 14009:2020

ISO 14008:2019

ISO 14006:2020

ISO 14005:2019

ISO 14004:2016

ISO 14001:2015

ISO 14000

ISO 9000

ISO 50001

ISO/DTS 14074

ISO WD 59 020

ISO WD 59 014

ISO WD 59 010

ISO TR 59 032

ISO TR 59 031

ISO NWP 59 040

ISO/WD 59004

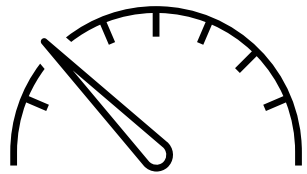
Legend

- Design phase
- Acquire material phase
- Produce product phase
- Use and consume phase
- End of life phase
- Circular Economy specific
- Life cycle standard
- Under development
- Information flow

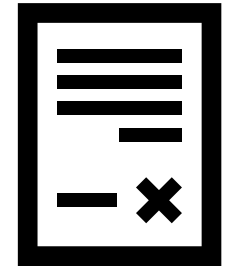
# Operationalizing Manufacturing Decarbonization



Design



Measurements



Standards



Circular System  
Analysis




USG National Standards Strategy for Critical and Emerging Technology supports the development of federal standards policy to ensure continued U.S. global economy competitiveness and technology leadership





# DEVELOPING A USG NSSCET IMPLEMENTATION PLAN

A background graphic on the left side of the slide features a white robotic arm with blue joints, positioned diagonally. Behind the arm is a semi-transparent blue rectangle. The entire background is decorated with white circuit-like lines and small circular nodes, giving it a technological feel.

NIST as point of entry to engaging on the USG National Standards Strategy for Critical and Emerging Technology

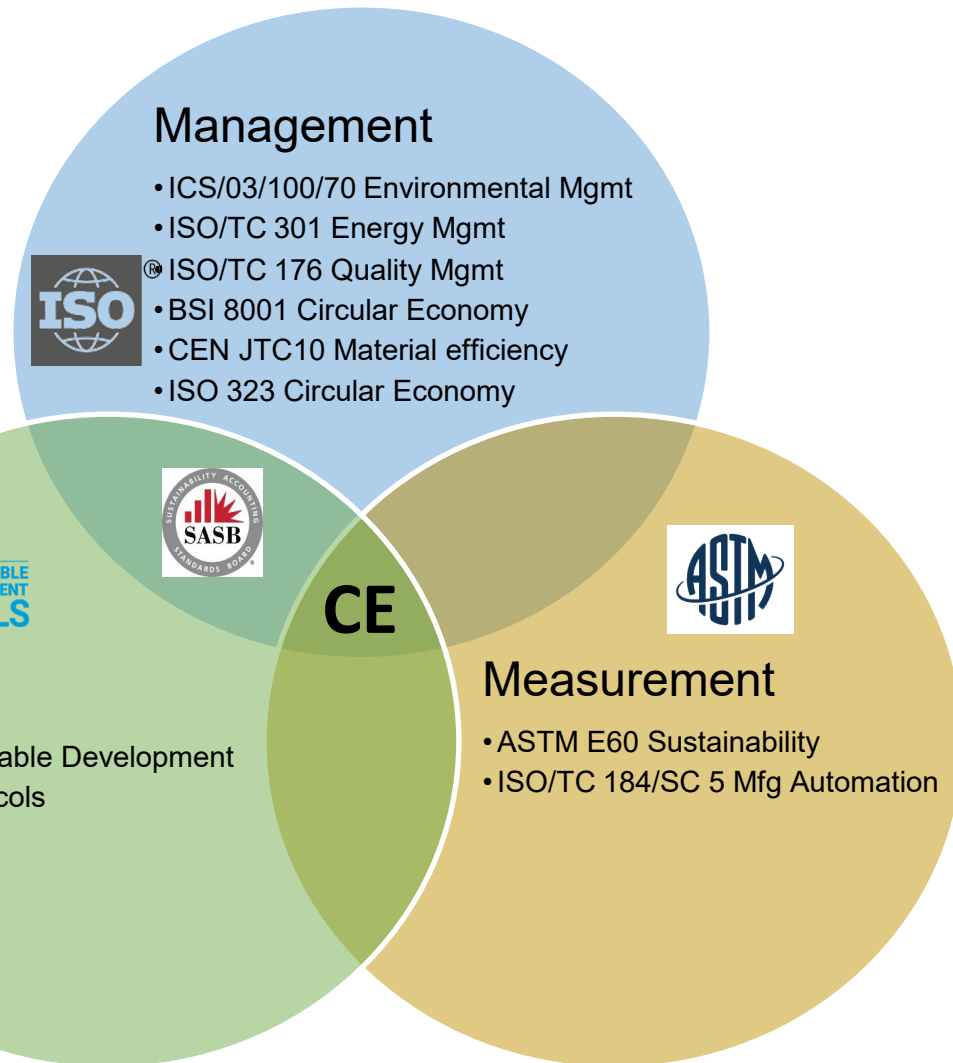
Supporting communication and coordination information **standards.gov**

Hosting **National listening sessions** and stakeholder engagement workshops (planning 6 sessions between September and December, 2023)

Established **Visiting Committee on Advanced Technology Subcommittee** on International Standards Development

Posting **Request for Information** on barriers to increased standards engagement (FRN at the end of August)

# International Standards Efforts for Circular Economy



## New Standards Supporting CE

### ISO 323 Circular Economy

- 5 Working Groups on technical content
- 6 standards under development
- High participation with 1 vote per country

### ASTM E60.13 Sustainable Manufacturing

- New Work Item:  
Principles for Circular Product Design
- Report:  
*ASTM Symposium Report Roadmapping Standards for Circular Economy*
- Broad participation with 1 vote per organization

### Others

- include technology, material, sector specific

# CE Standards Efforts: ISO and ASTM



## **ISO/TC 323 on Circular economy**

- Foundations for a shift to CE
- Macro-level management
- Representatives from countries

*Credit: ISO*



## **ASTM International Committee E60 on Sustainability**

- Support sector-specific standards
- Operations – principle and performance standards

*Credit: ASTM International*



# ISO/TC 323 Circular Economy Standards

**ISO 59004**  
Terminology,  
principles, frameworks  
and guidance for  
implementation

- Define a CE
- How can we implement a CE?
- How does CE contribute to the UN SDGs?

**ISO 59010**  
Guidance on business  
models and value  
networks

- Business-oriented guidance
- Practical approaches for implementing a CE
- E.g., goal setting, circularity problems to be addressed

**ISO 59020**  
Measuring and  
assessing circularity

- CE metrics
- How to measure success?
- Aligned with ISO management, LCA standards

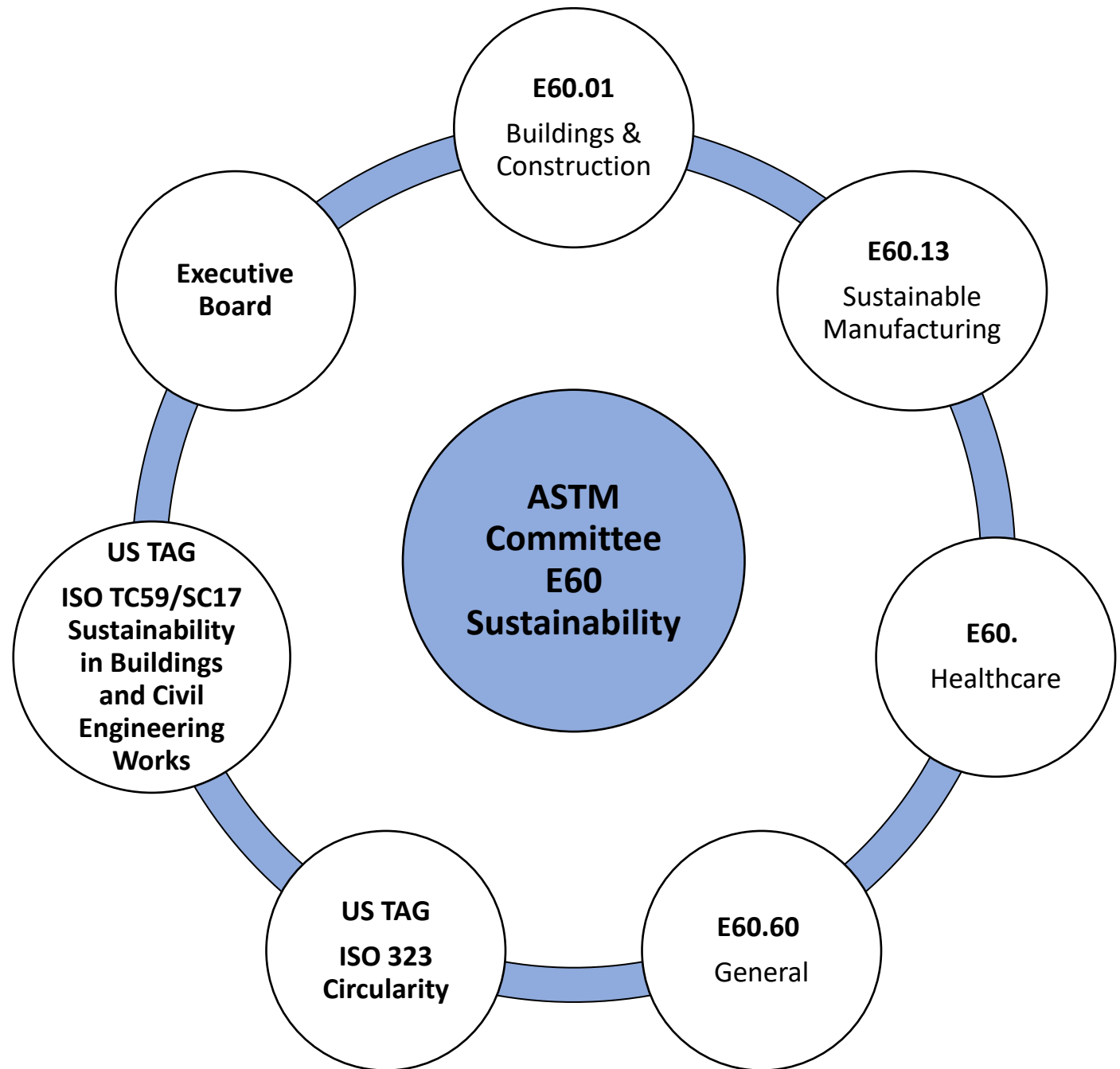
**ISO 59040**  
Product Circularity  
Datasheet

- Provides a method of passing CE information
- How to manage CE information
- Intended for conformity assessment

**February 2024**

**Early 2025**

# ASTM E60 Sustainability



# Roadmap released for standards from ASTM Circular Economy Workshop



## Manufacturing in a Circular Economy

### Fostering a Circular Economy of Manufacturing Materials Workshop Report

This report presents the key outcomes from the Workshop: "Fostering a Circular Economy of Manufacturing Materials" jointly organized by ASTM International and NIST, key takeaways from the proceeding Survey: Manufacturing in a Circular Economy, and next steps for addressing the standards needs identified in both.

In addition to the standards identified, two key takeaways stemmed from the survey and workshop: first, participants have a transformative, though fragmented, vision for a new way of thinking about how we create and use materials that is regenerative rather than extractive.

Second, participants are motivated to make this vision come true, and they are indicative of a larger desire across the manufacturing sector to implement circularity.

ASTM Committee E60 on Sustainability is well-suited to play a part in developing and coordinating standards that foster a circular economy for manufacturing materials.

Download and read more in the full report.

#### Download Report



Download Report



# ASTM International E60 on Sustainability

## Foundational Standards for a CE

- Definitions/Terminology
- Reporting
- LCA/LCIs

## Systems Support Standards

- Systems Thinking
- Traceability & Digital Records
- Labeling

**Front-End  
Design**

**Manufacturing  
Production**

**Back-End  
Recovery**

**Recycling  
Related**

New Work Item:

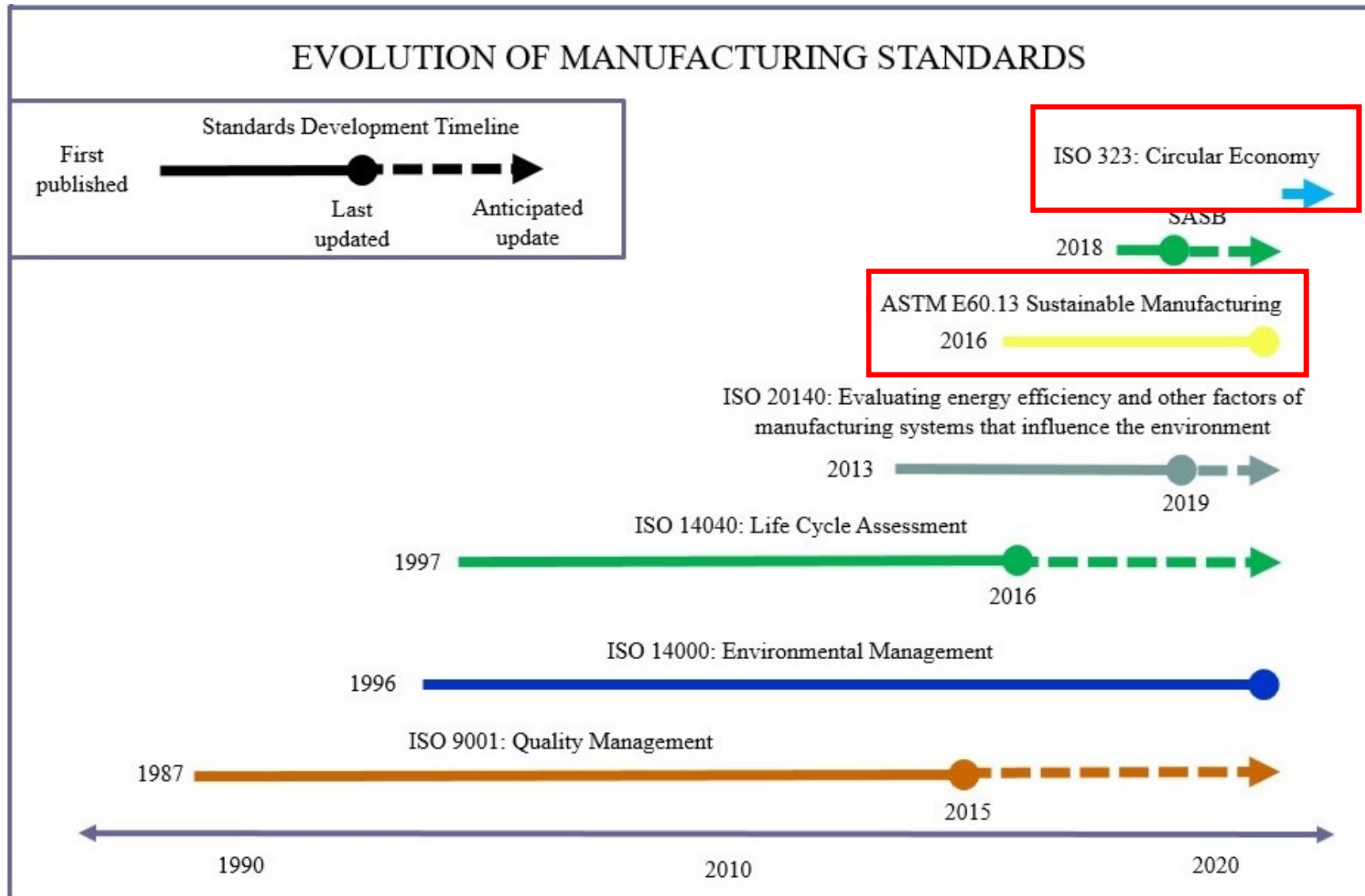
*A Guide to Principles for Circular Product Design*

- Main standard: general principles for CPD
- Appendices: sector-specific principles and guidelines

More to come...volunteers needed

Fostering a Circular Economy of Manufacturing Materials

# Conclusion



# Our NIST Team



KC Morris



Nehika  
Mathur



Vincenzo  
Ferrero



Matt Triebe



Noah  
Last



Buddhika  
Hapuwatte



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# Get Involved



## Committee E60 on Sustainability

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## ISO TC 323 on Circular Economy

TAG Co-chairs

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<https://www.nist.gov/circular-economy>



# References

- Ekvall, T., Albertsson, G. S., & Jelse, K. (2020). Modeling recycling in life cycle assessment. IVL Svenska Miljöinstitutet. <http://urn.kb.se/resolve?urn=urn:nbn:se:ivl:diva-27>
- Escoto, X., Gebrehewot, D., & Morris, K. C. (2022). Refocusing the barriers to sustainability for small and medium-sized manufacturers. *Journal of Cleaner Production*, 338, 130589. <https://doi.org/10.1016/j.jclepro.2022.130589>
- Reslan, M., & Last, N. (2022, September 25). The Need for a Standards Roadmap for Manufacturing in a Circular Economy [Conference Presentation]. Smart Manufacturing and Logistics Systems: Turning Ideas into Action, Gyeongju, Korea. <https://www.apms-conference.org/past-conferences/apms-2022/>
- Schrijvers, D. L., Loubet, P., & Sonnemann, G. (2016). Developing a systematic framework for consistent allocation in LCA. *The International Journal of Life Cycle Assessment*, 21(7), 976–993. <https://doi.org/10.1007/s11367-016-1063-3>
- Schumacher, K., Last, N., Morris, K., Costello, A., Hapuwatte, B., Mathur, N., Ferrero, V., & Reslan, M. (2023). Fostering a Circular Economy of Manufacturing Materials Workshop Report [Workshop Report]. ASTM International.
- <https://www.whitehouse.gov/briefing-room/statements-releases/2022/11/04/fact-sheet-biden-harris-administration-makes-historic-investment-in-americas-national-labs-announces-net-zero-game-changers-initiative/>
- <https://www.whitehouse.gov/ostp/news-updates/2023/02/22/readout-of-the-white-house-circular-economy-innovation-roundtable/>
- <https://www.whitehouse.gov/ostp/news-updates/2023/07/05/advancing-a-circular-economy-to-meet-our-climate-energy-and-economic-goals/>