
# Cummins Solid Oxide Electrolyte Manufacturing

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DOE Manufacturing Automation and Recycling for Clean Hydrogen Technologies

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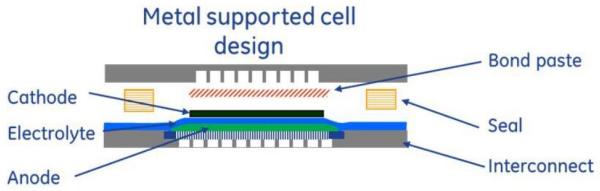
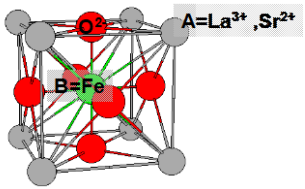
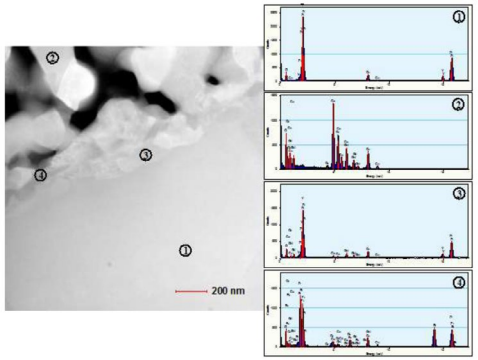
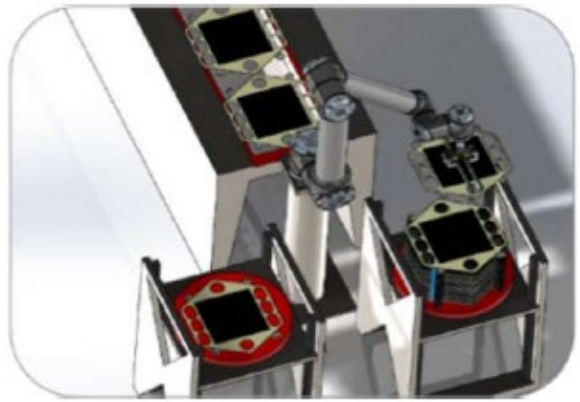
# Cummins SOxC manufacturing evolution







2002-2007
Process / Thermal Spray proof of concept

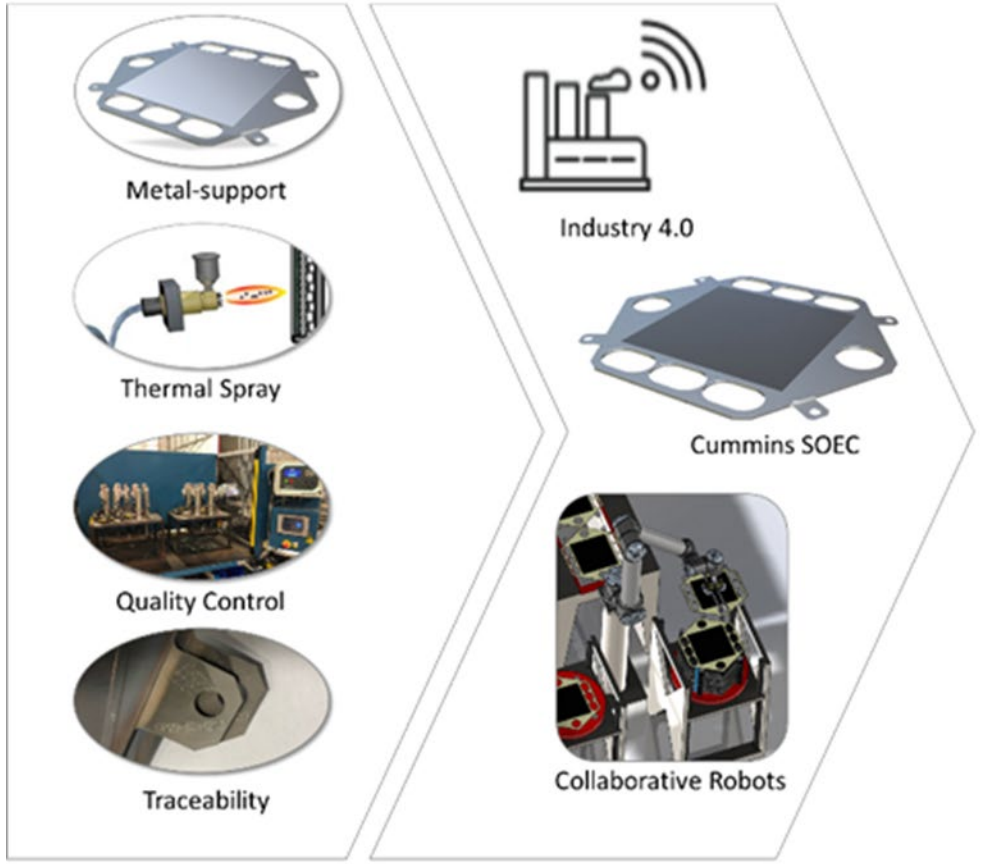
2008-2013
Preventing Materials Degradation; Materials set down-select

2014-2019
Cell & Stack Development

2020-2022
High-Volume Prototyping

- Metal-supported cell designed for manufacturability
- Large & scalable cell size

# Cell and Stack Manufacturing

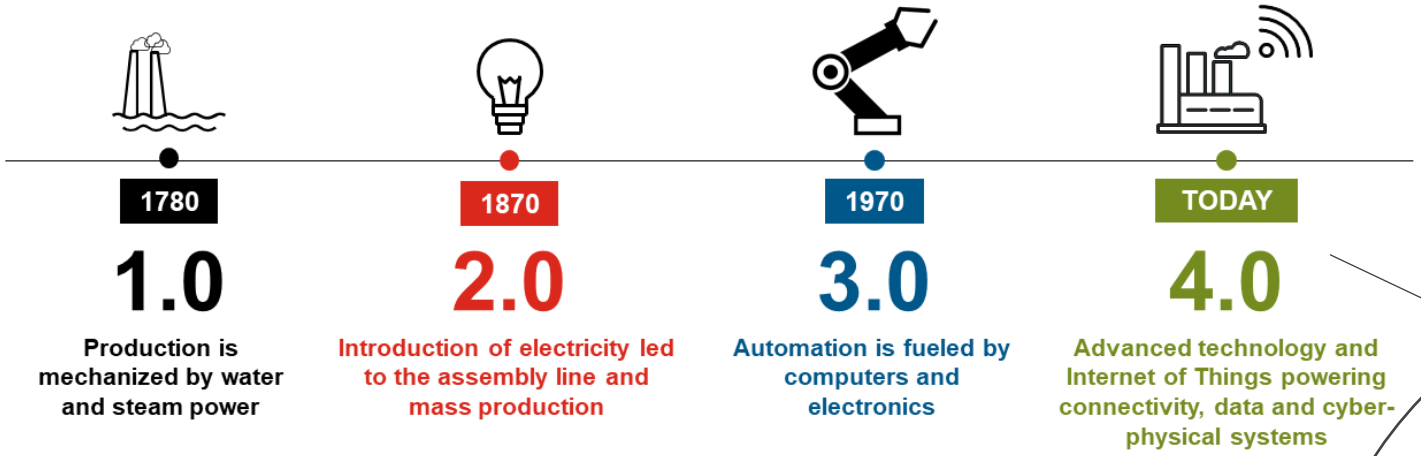



Key Enablers
Metal-support is durable
Additive approach is sequential
Quality control is fast and non-destructive
All cells are traceable

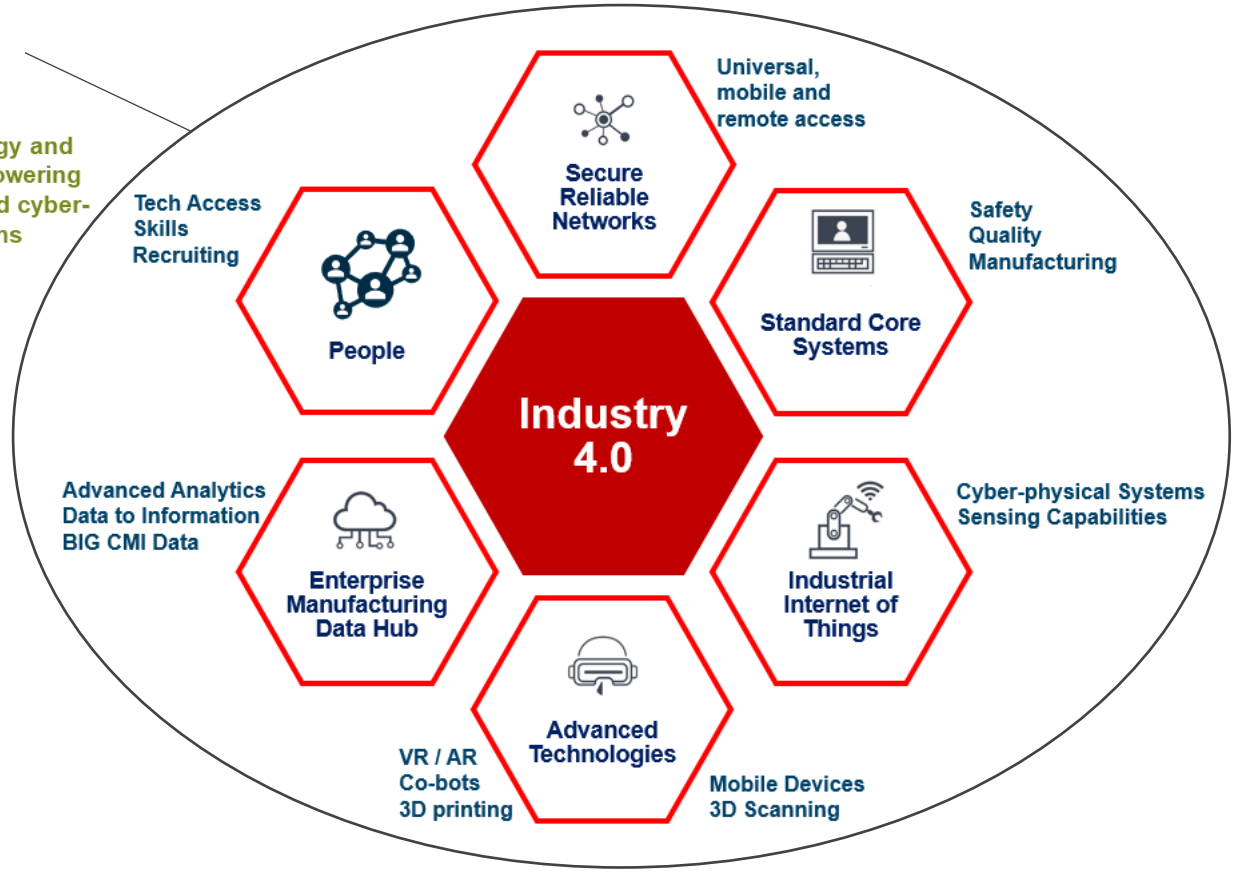
Key Initiatives
Design for I4.0 technology early
Leverage collaborative robots for early flexibility

Today's objective: demonstrate processes & equipment to hit takt time, CapEx, direct labor & space targets

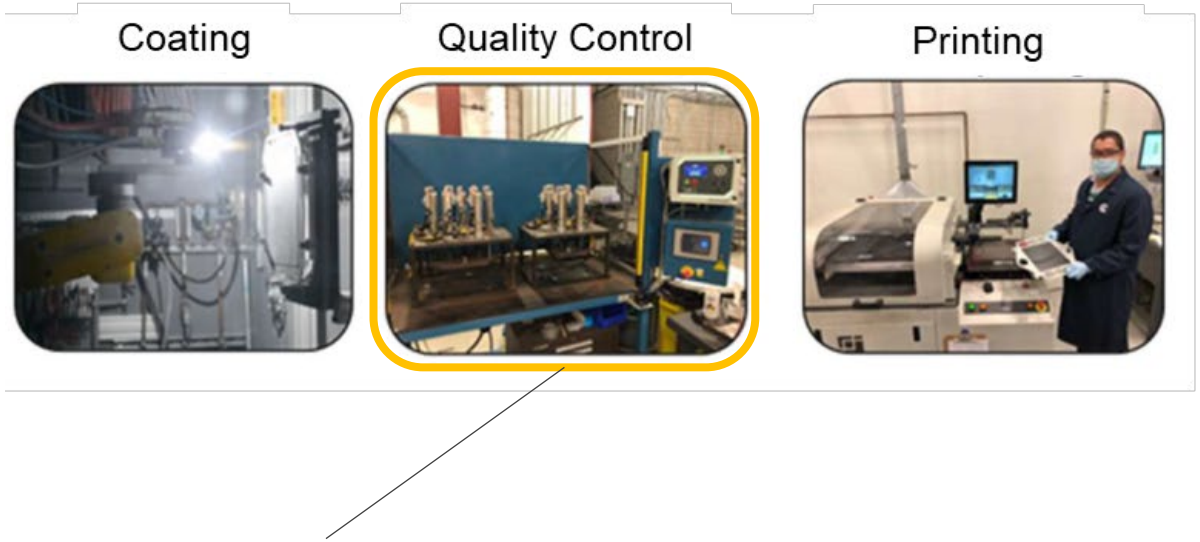
# Cummins I4.0 Initiative




- Corporate manufacturing initiative for more holistic and better-connected manufacturing systems
- For SOxC → optimize processes early for high-volume equipment, connectivity & process control

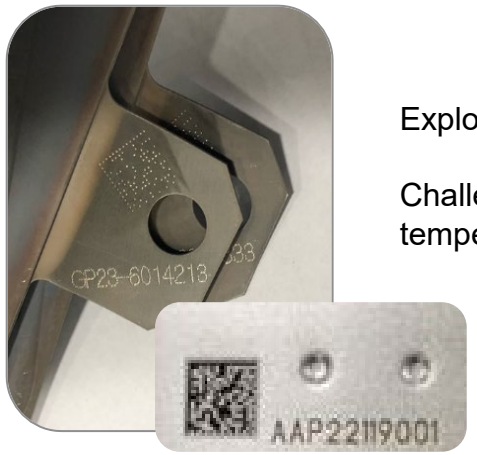


# Quality Control





- Quality Control is a major emphasis
- Traceability of parts will be very important
  - 100% inspection
  - 100% read rate
  - 100% identification of defects
  - 100% removal of defects
- Automate QC, design processes & equipment early for easy implementation of controls & data acquisition

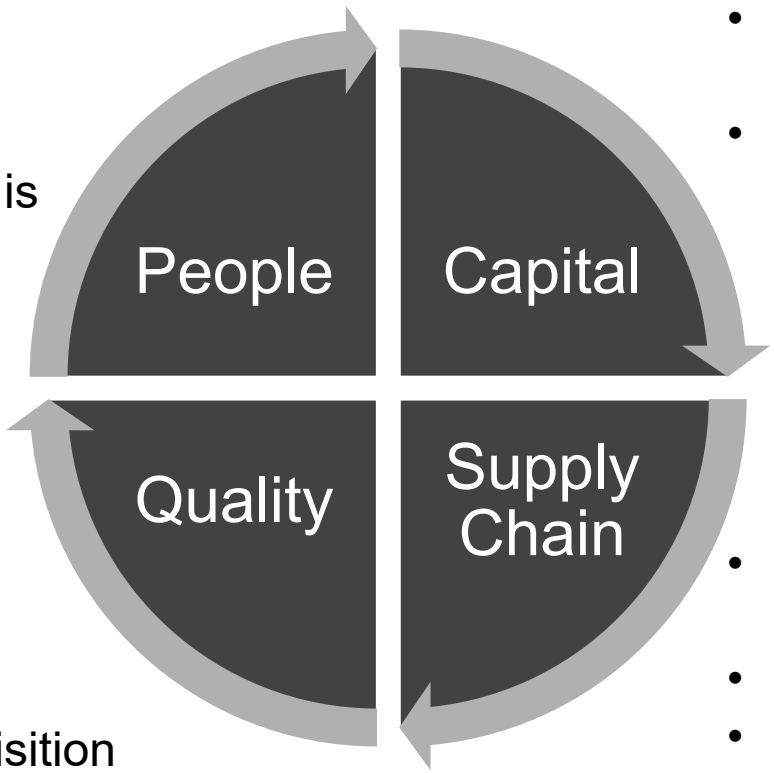



Exploring mechanical and laser marking

Challenge is readability after high-temperature operation

# Considerations to Scale

- Recruit for skills
- Maintain culture during growth – keep people emotionally invested
- Invest in training, cross-pollinate
- Embrace & acknowledge change is hard




- Cost-effective equipment & integration
- Grow capacity with demand, aim for modularity
- Domestic equipment suppliers, time is important

- Reproducibility at volume – every piece of equipment is unique
- Correlate, validate, predict
- Systematic commissioning
- Traceability, controls & data acquisition
- Standardize processes to be operator independent

- Cost-effective suppliers at low volume that can scale, look for mutual benefit
- Design for manufacturability
- Consider line balancing, buffering, queuing
- Leverage existing industries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