Cognitive Agents to Advance Sustainable Manufacturing

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Cognitive Agents to Advance Sustainable Manufacturing

- Sustainable Manufacturing Definition / Metrics
- Why consider cognitive agents to advance sustainable manufacturing?
- Potential for Cognitive Agents in Sustainable Manufacturing
  1. Energy and Carbon Management & Beyond
     - Supply Chain
     - Factory Operations
  2. Process Selection
     - Metalworking Fluids
     - Additive vs. Subtractive Manufacturing
  3. Life Cycle Design
  4. Remanufacturing
  5. Cognitive Regulation

Is Manufacturing Environmentally/Socially/Economically Important?

$1.65 Trillion value in U.S.

>300,000 facilities

36% of Industrial CO2 Emissions

20% of U.S. Energy Consumption

6B tonnes of solid waste per year

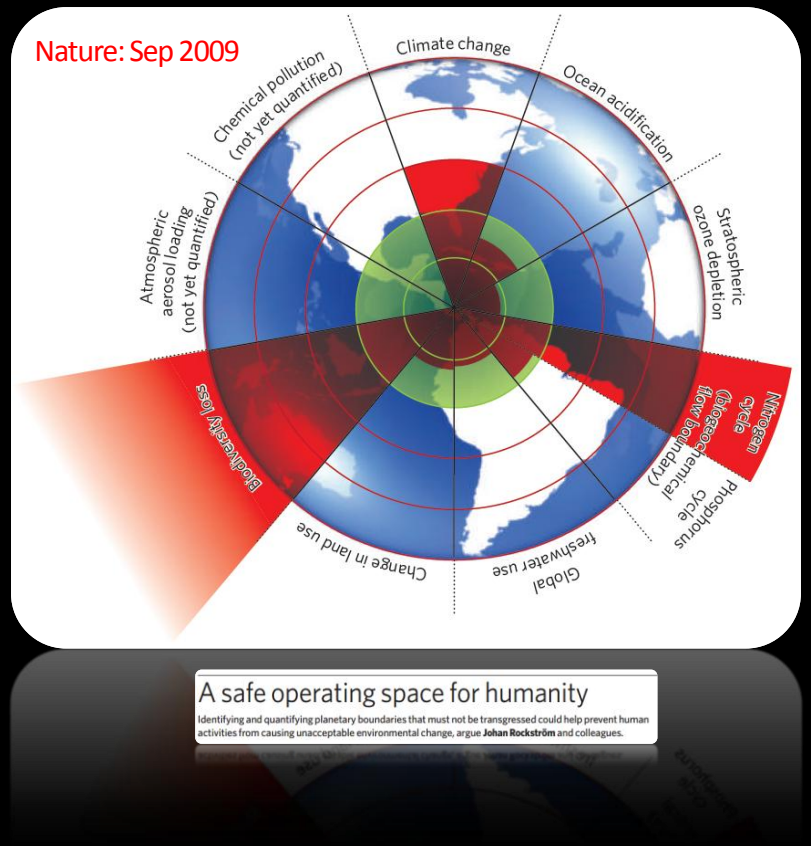
Contributor to Non-Attainment Air Zones

Not yet quantified:

Impact on air/water chemical release

Impact on human health and ecosystems

Impacts on development in supply chain



Sustainable Manufacturing

"…the creation of manufactured products using processes that minimize negative environmental impacts, conserve energy and natural resources, are safe for employees, communities, and consumers, and are economically sound"

US Department of Commerce

Selection of Metrics for Sustaianble Manufacturing: Triple Bottom Line: People, Prosperity, Planet

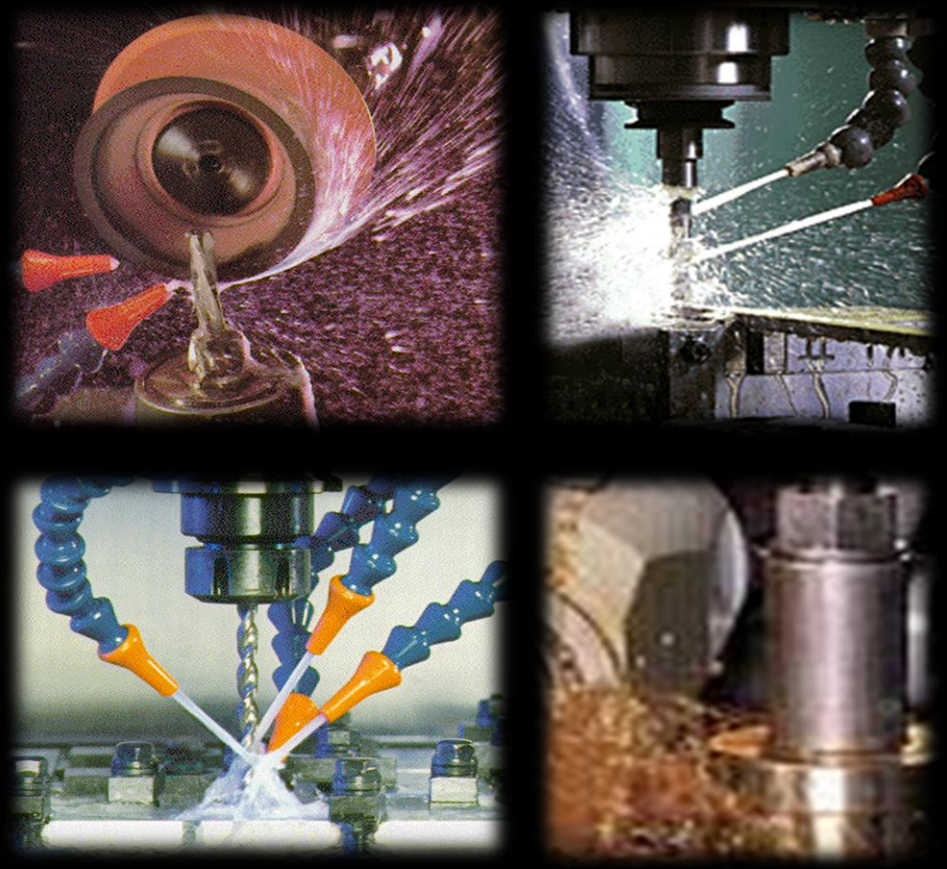
Environmental Impact	- GHG emission (ton CO_2 eq./unit) - Ratio of renewable energy used (%) - Total water consumption (ton/unit)
Energy Consumption	- In-line energy consumption (kWh/unit) - Energy consumption on maintaining facility environment (kWh/unit) - Energy consumption for transportation into/out of the line (kWh/unit)
Cost	- Labor cost ($/unit) - Cost for use of energy ($/unit) - Maintenance cost ($/unit)
Operator Safety	- Exposure to corrosive/toxic chemicals (incidents/person) - Injury rate (injuries/unit) - Near misses (near misses/unit)
Personal Health	- Chemical contamination of working environment (mg/m^3) - Mist/dust level (mg/m3) - Physical load index (dimensionless)
Waste Management	- Mass of disposed consumables (kg/unit) - Consumables reuse ratio (%) - Ratio of recycled chips and scraps (%)

(Haapala et al., 2013)

What could cognitive agents, with their big data, ubiquitous sensing, unstructured learning and perception bring to sustainable manufacturing?

- Unstructured learning that can identify waste and pollution at the factory and align the product life cycle with corporate sustainability objectives.
- Scalability that sustainable manufacturing education cannot achieve.
- Cascading targets to organizational operations based on knowledge regarding possibilities for improvement.
- Navigating multiple objective functions simultaneously, since sustainability is multidimensional.
- Facilitate creation of corporate targets and governmental regulation.
- Provoke *questions* that are not currently being asked.

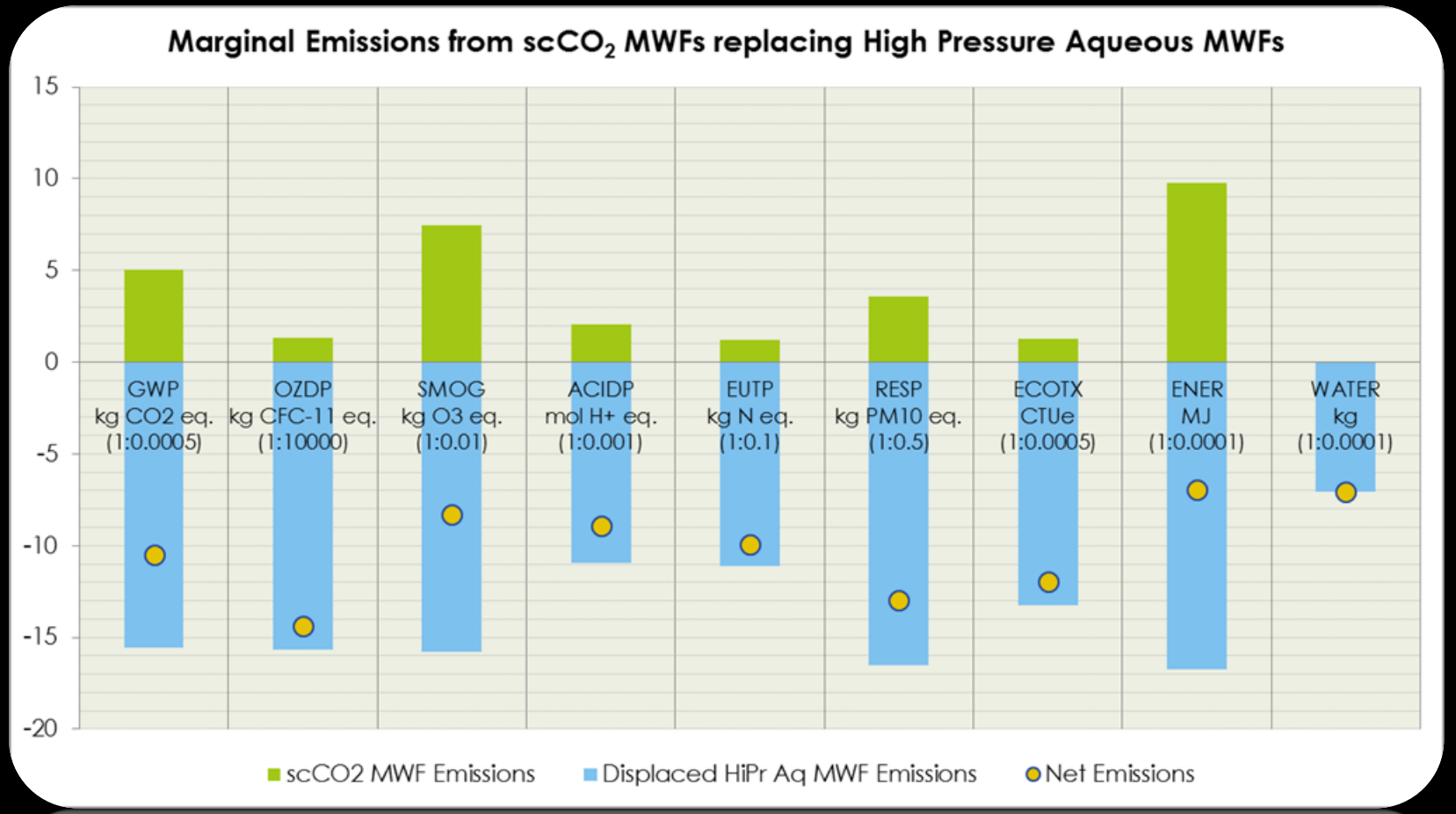
After Cognitive Carbon Management
Cognitive Process Selection



Vs.

Process Alternative: Rapidly Expanding Sprays of Supercritical Carbon Dioxide

Supercritical Carbon Dioxide vs. High Pressure Water



After Cognitive Carbon Management
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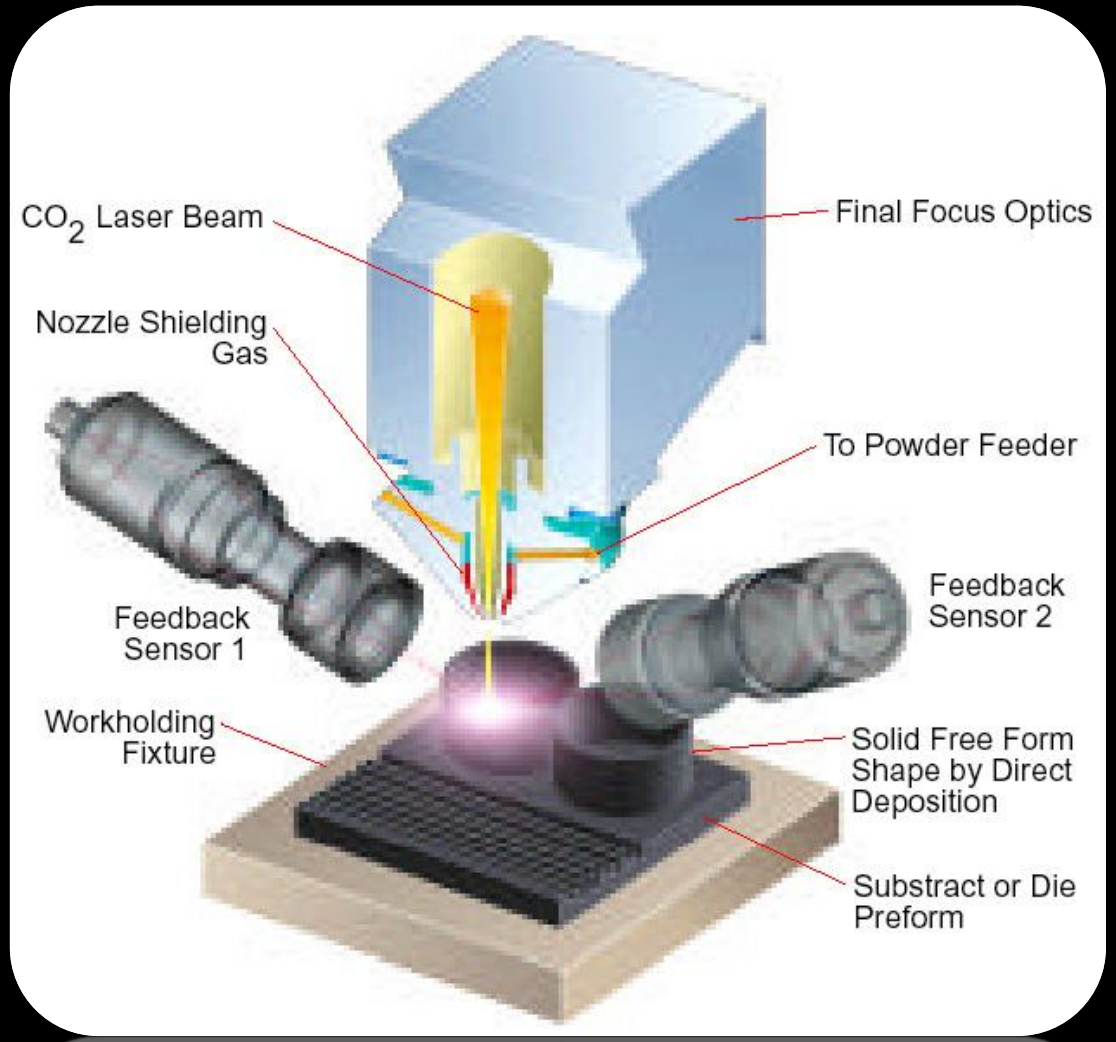
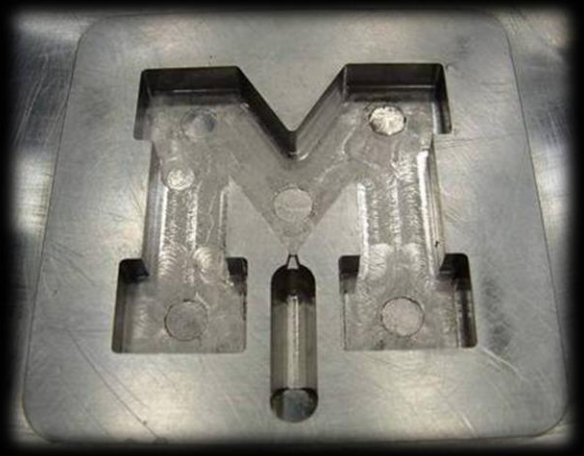
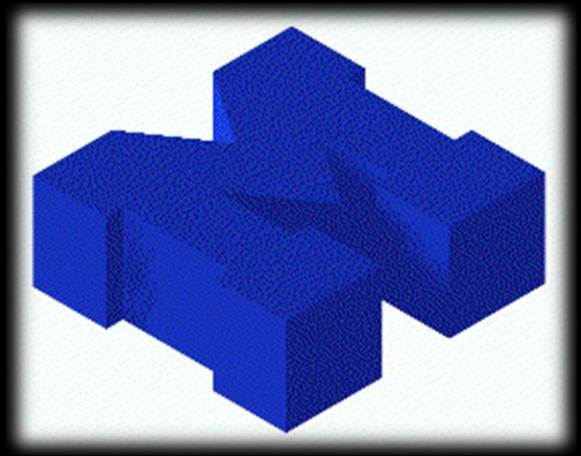
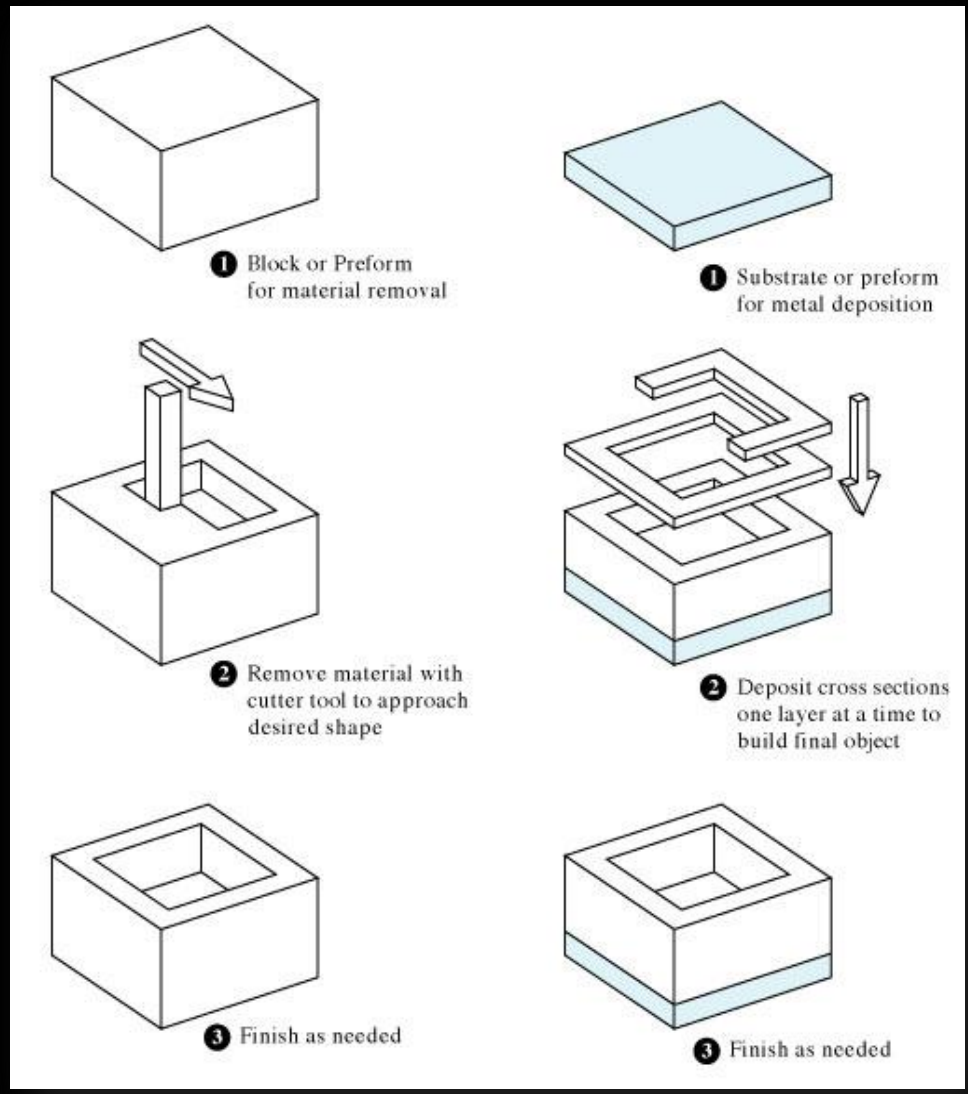


(Morrow et al., 2007)

Which uses less energy: additive or subtractive pathway?

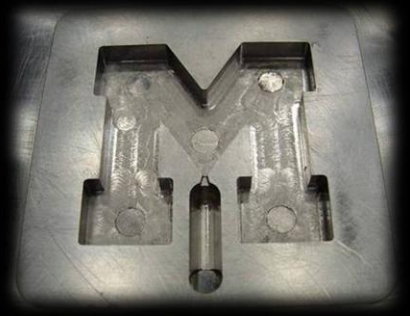


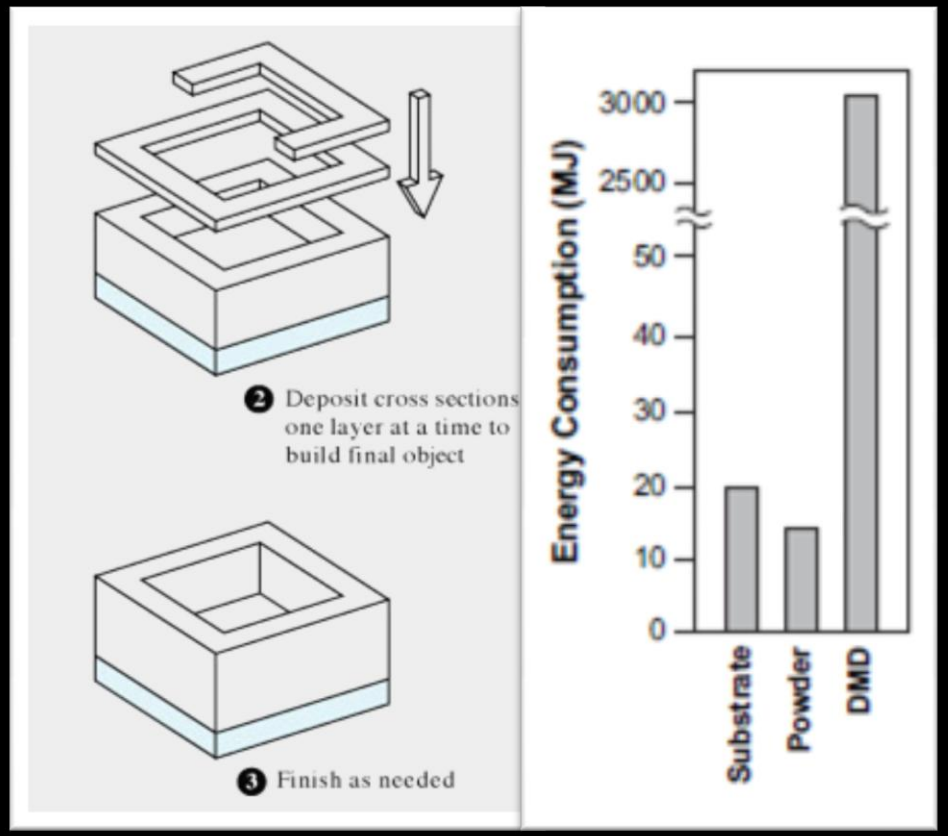




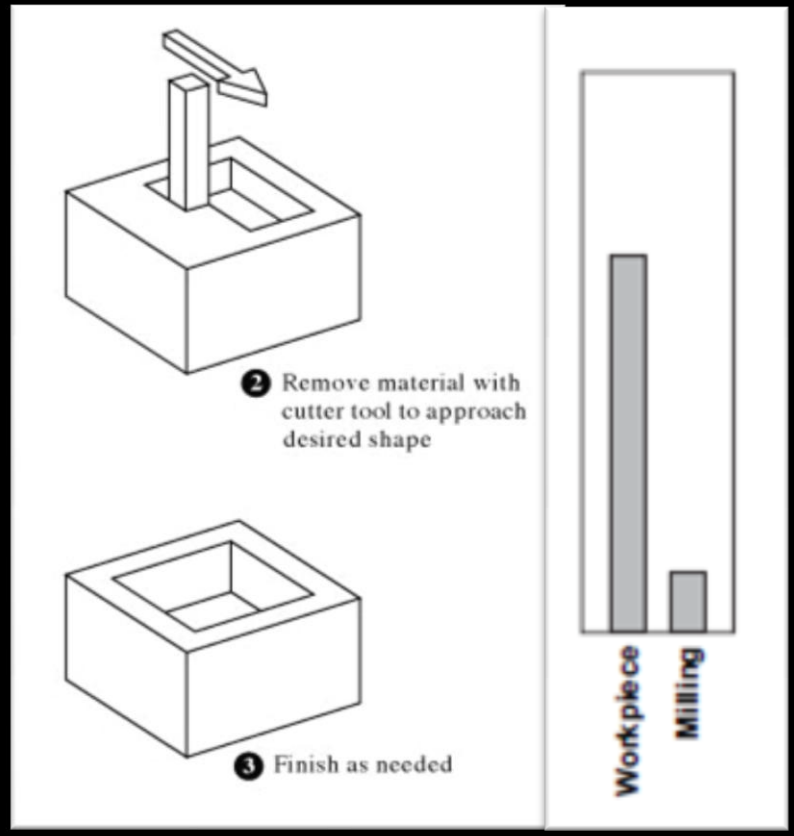
(Morrow et al., 2007)

significant energy/environmental differences between additive and subtractive pathways



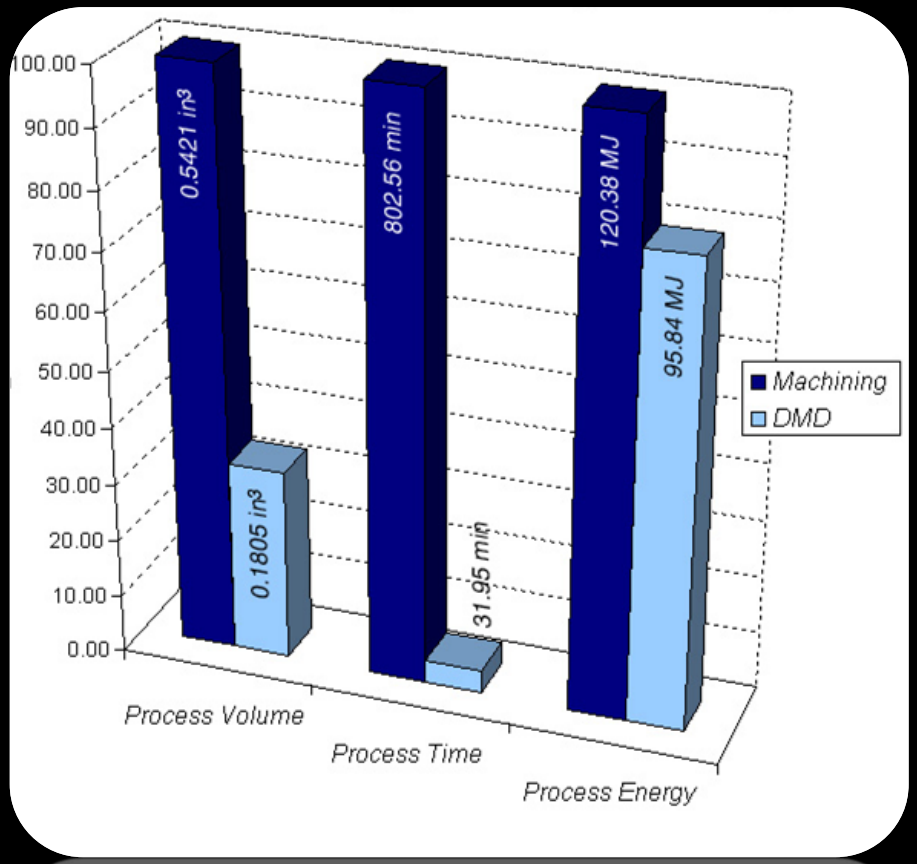


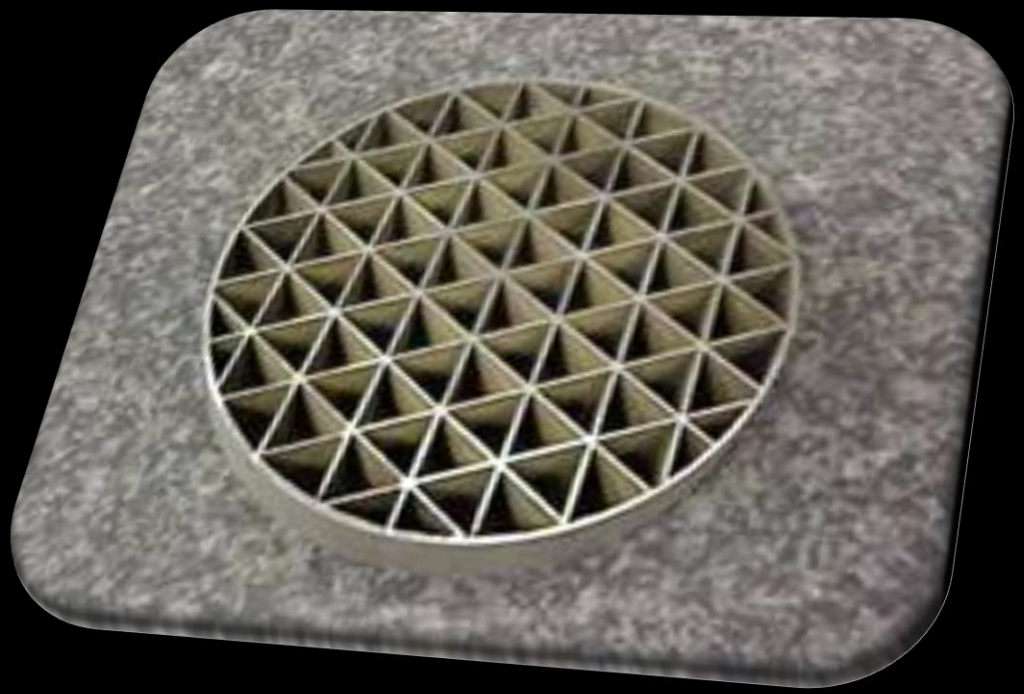
Vs.



(Morrow et al., 2007)

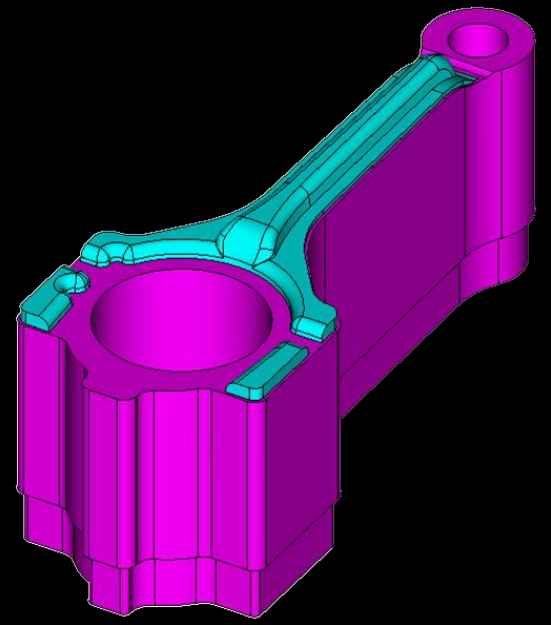
Mirror Backing for Space Application



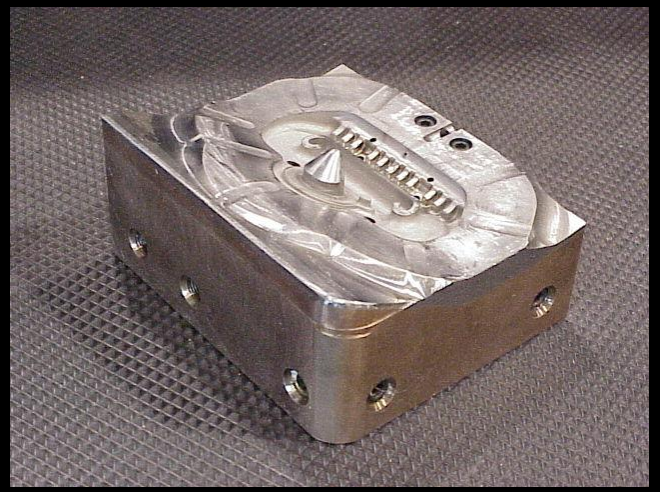


(Morrow et al., 2007)

Cognitive Agents in Sustainable Manufacturing: Manufacturing Tooling Design



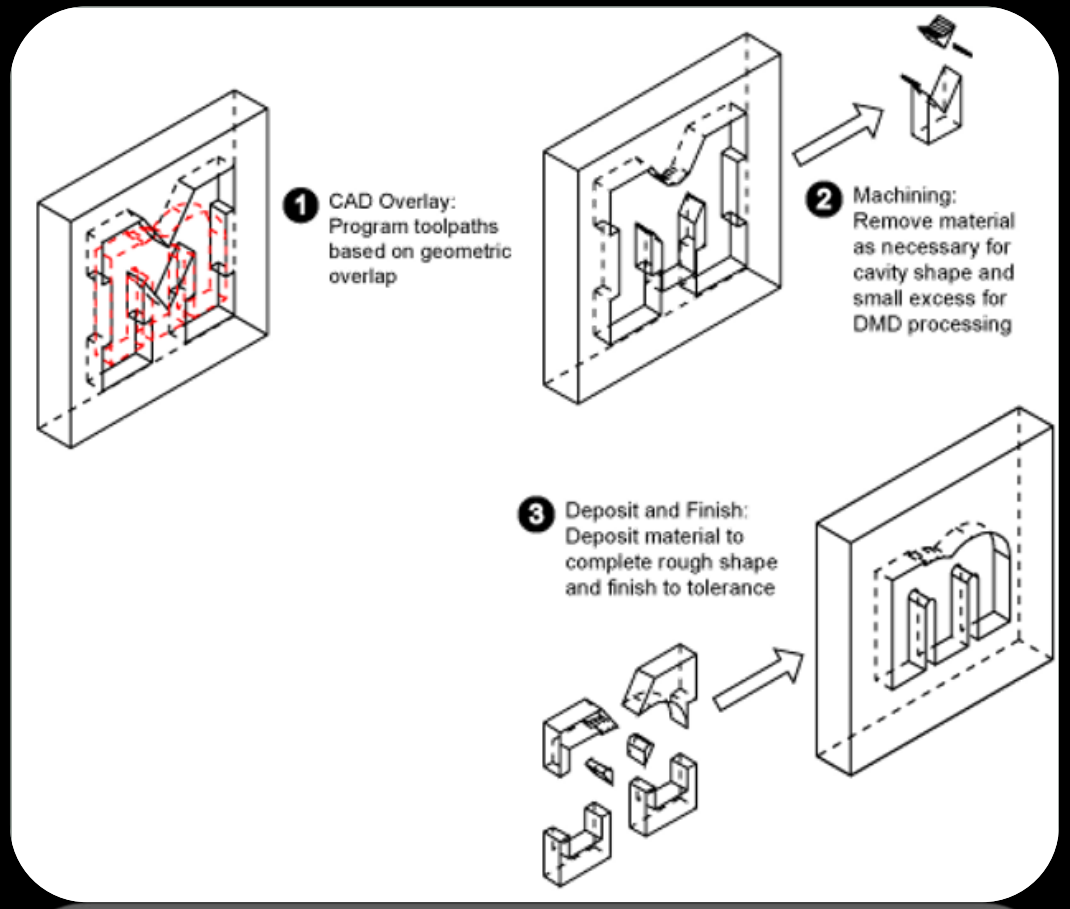
- Application of Highly Wear Resistant Alloys
  - Tool life increases by factor of 3.
  - Manufacturing system productivity increases by 5%.
  - Air/water emissions reduced by several million pounds per year.
- Increased Part Production Rates
  - 25% faster production than currently possible.
  - Electricity consumption reduced by 125,000kW*hr
  - CO2 reductions by 20 tons.
  - Recycling processes needed but not impossible.



Cognitive Agents in Sustainable Manufacturing: Remanufacturing and Closed Loop Supply Chains

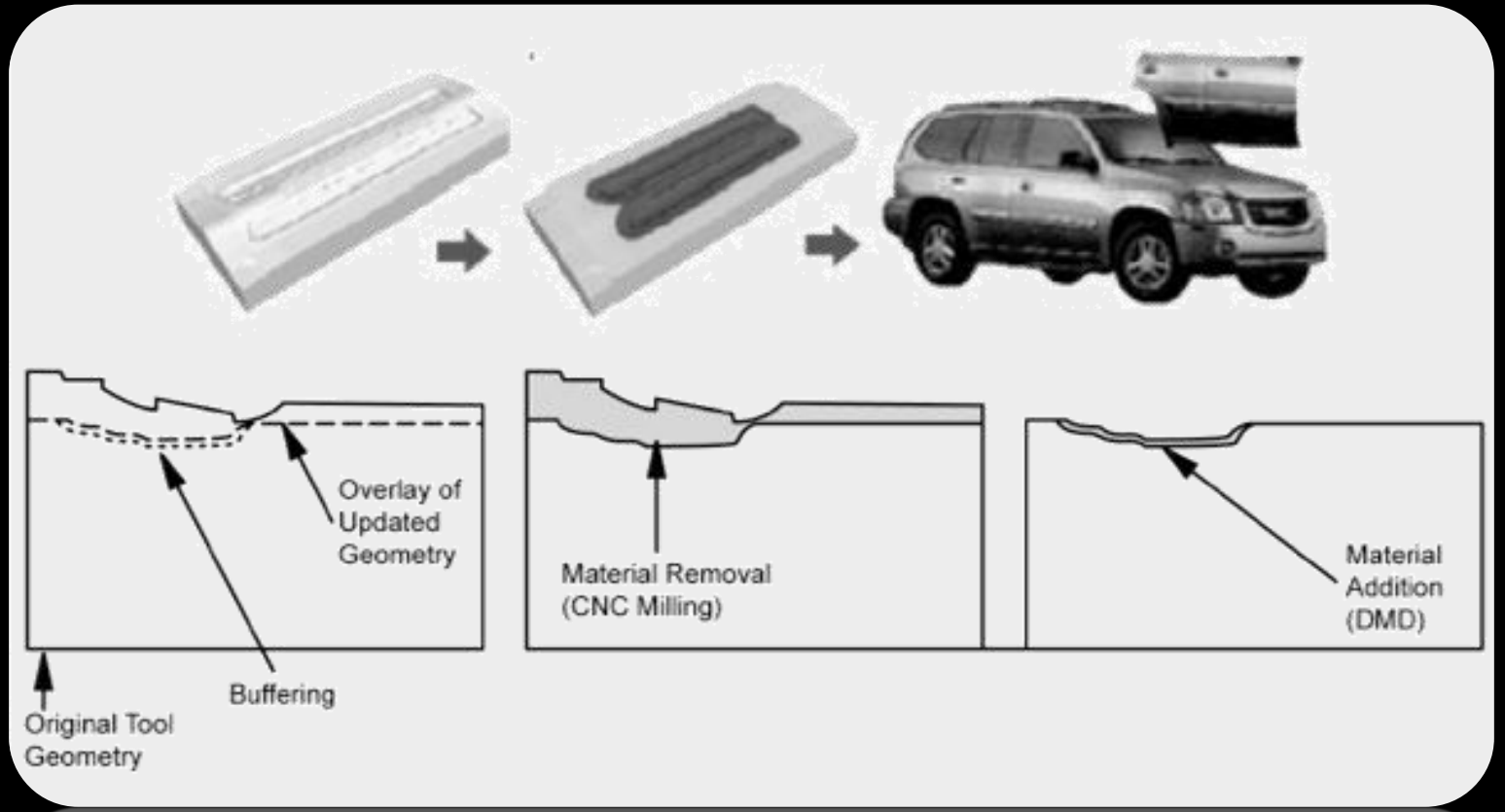
Potential for:

- Environmental Savings
- Economic Savings
- Reduced lead time
- Job Savings



Cognitive Agents in Sustainable Manufacturing:

Remanufacturing and Closed Loop Supply Chains

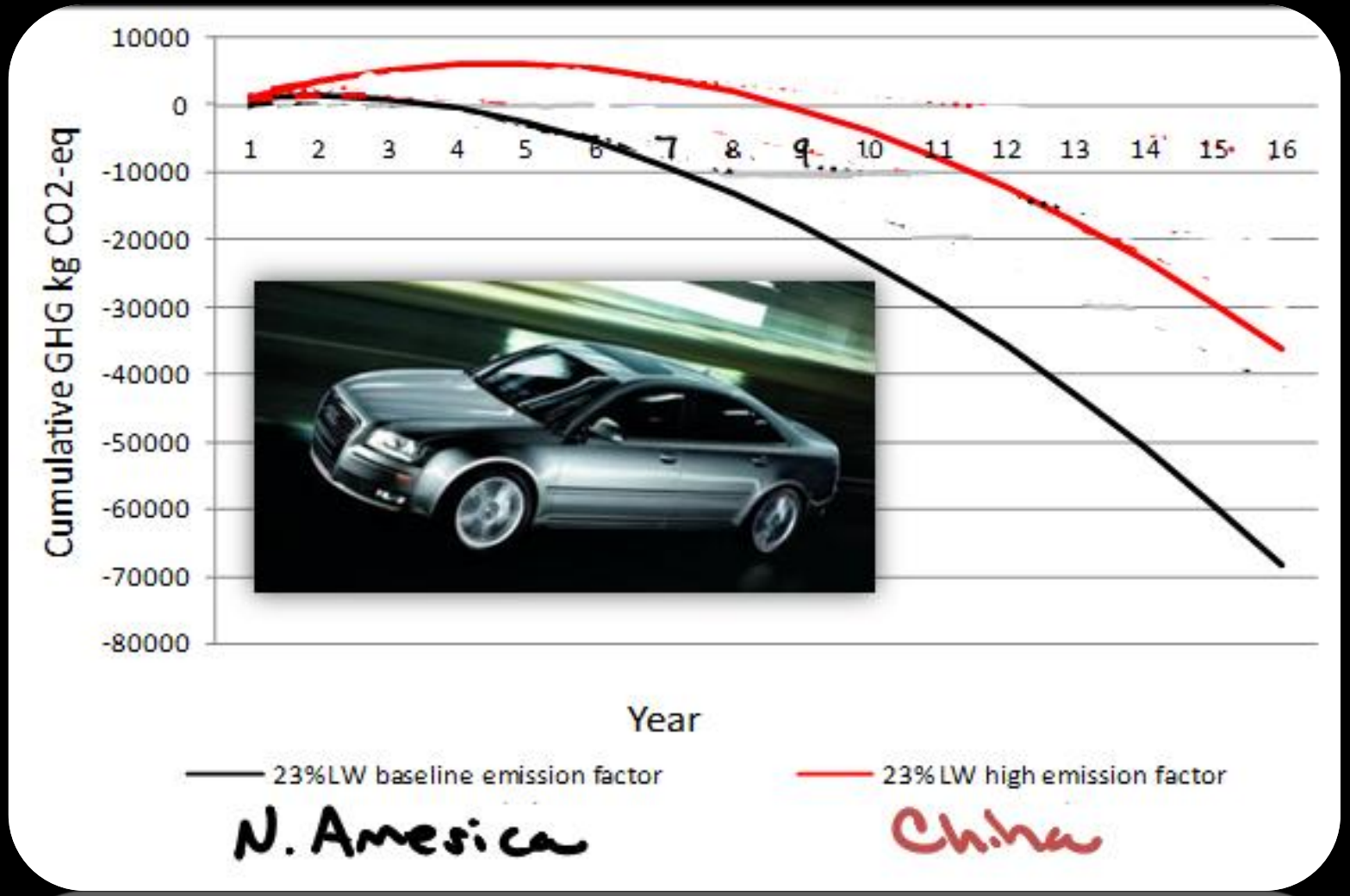


- 10 ton tool converted via minimal combined additive/subtractive operations.
- Ton of CO2 eliminated, for material production alone!
- Not to mention: $250K and 35% lead time reduction.

(Morrow et al., 2007)

Cognitive Agents to Promote Sustainable Manufacturing

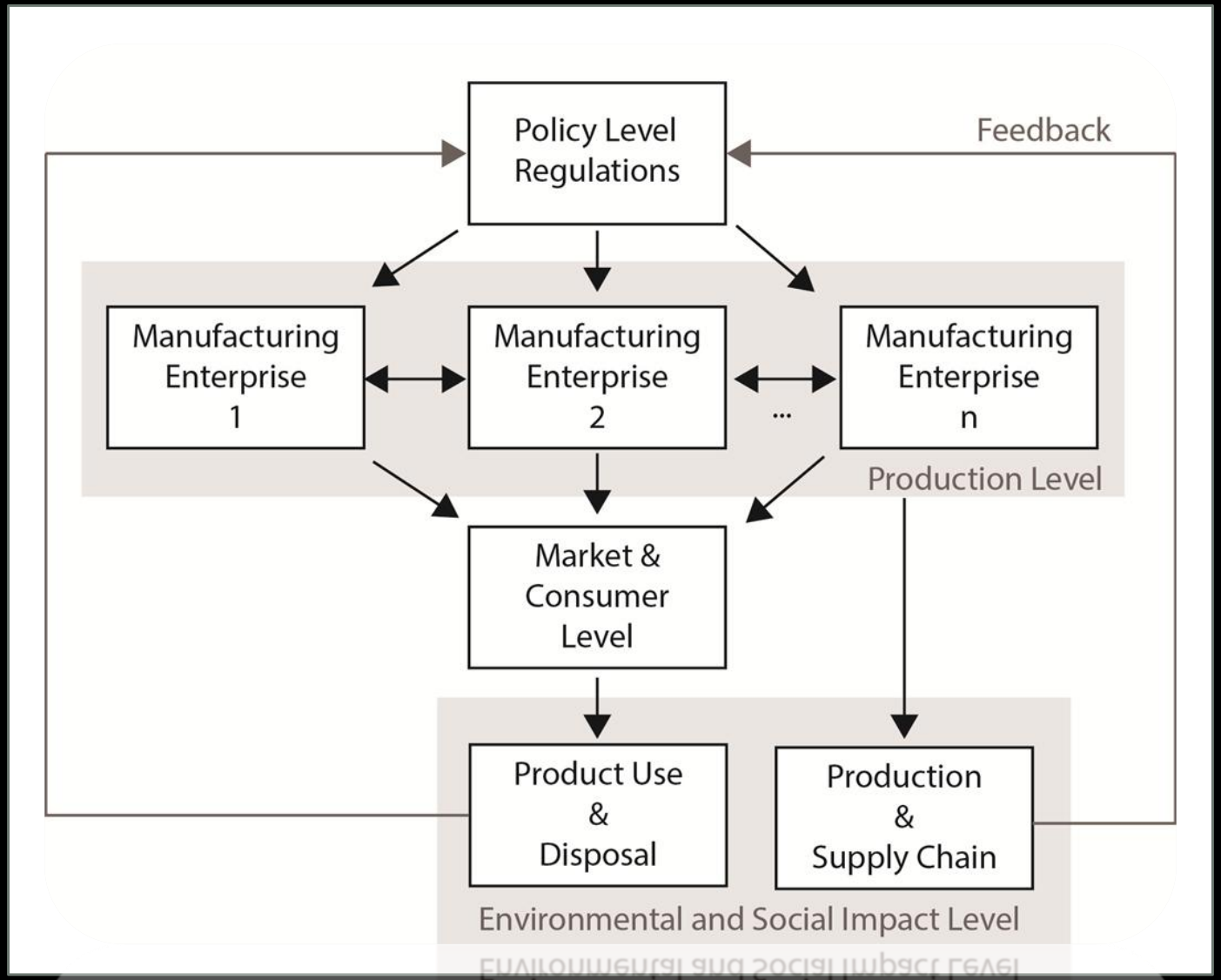
Interactions of Supply Chain, Design, and Life Cycle Emissions



(Kim et al., 2011)

Cognitive Agents in Sustainable Manufacturing

Market-Aware Regulatory Strategy



(Whitefoot et al., 2012)

Are we stepping beyond the frontier?
Cognitive Agents can be explored to Advance Sustainable Manufacturing in:

1. Carbon Management of Factories and Supply Chains & Beyond
2. Health and Environmentally Conscious Process Selection
3. Tooling Design and Remanufacturing
4. Intersections of Supply Chain Function and Product Design
5. Policy Design

Cognitive agents should be explored to fully understand their potential to provide new levels of education to manufacturing systems, help navigate sustainability trade-offs and best leverage sustainability investments across its life cycle sphere of influence, while bringing a missing level of objectivity to sustainability discussions.