

# Advanced Manufacturing

Or the making of embodied energy

**Jimmy Jia**

[jimmy@jimmyjia.com](mailto:jimmy@jimmyjia.com)

**Last Edit: April 14, 2019**



This work is licensed under a [Creative Commons Attribution 4.0 International License](https://creativecommons.org/licenses/by/4.0/)

# Agenda

## AM

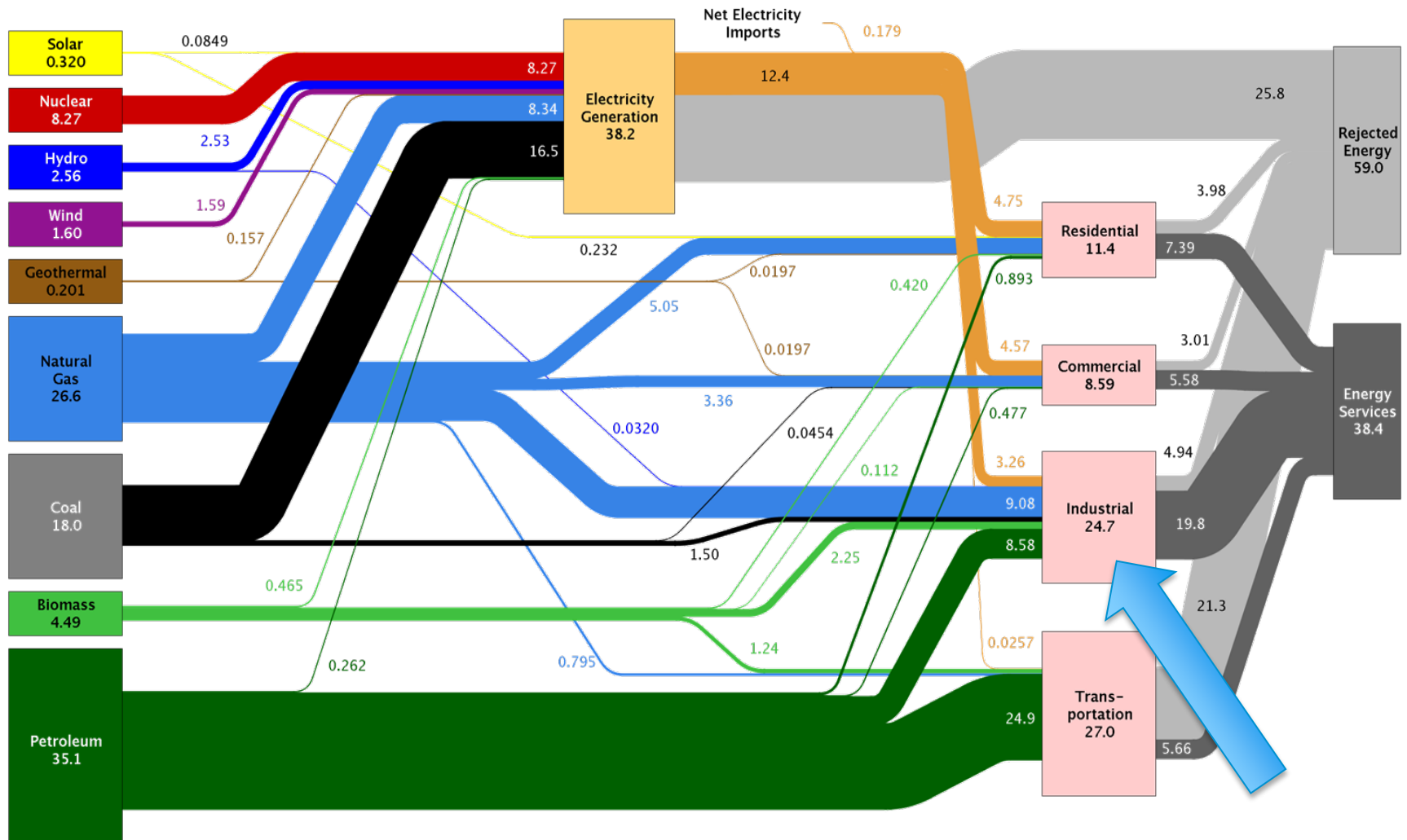
- Presentations
- Food and Agriculture

## PM

- Advanced Manufacturing
- Course Summary
- General Q&A once done

# Energy Consumed

Estimated U.S. Energy Use in 2013: ~97.4 Quads



# Manufacturing and Economy

In 2012, U.S. manufacturing was responsible for:

- 12.5% of GDP;
- Direct employment for about 12 million people;
- Close to 75% of U.S. exports of goods;
- Production of 17% of the world's manufacturing output; and
- 25% of U.S. energy use.

Source: U.S. Department of Energy

# What is Advanced Manufacturing?

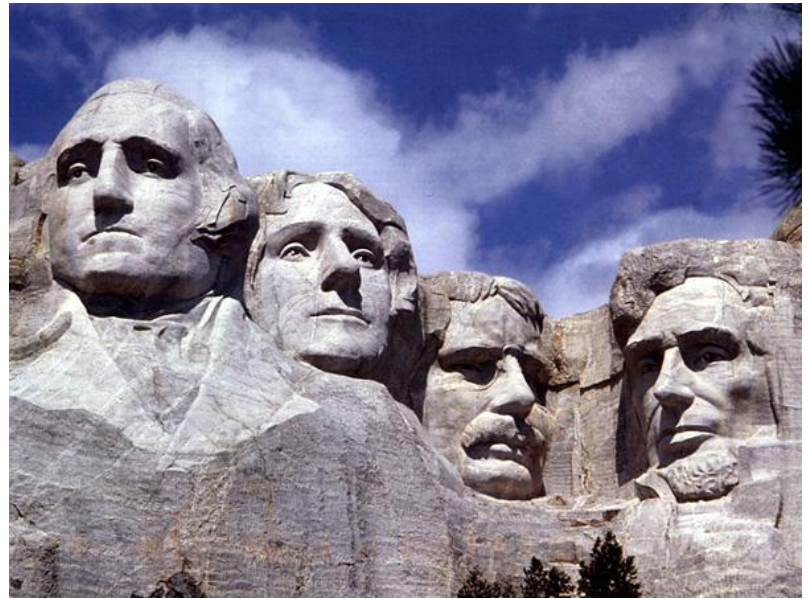
- **Conscious Raw Material Process** (eg. carbon footprint)
- **Design** — (eg. Computer Aided Design (CAD))
- **Planning & Control** — (eg. Six Sigma, Lean)
- **Technology** — (eg. automated equipment)
- **Workforce** — (eg. highly skilled workers)
- **Customer Satisfaction** — (eg. relationships, needs)
- **Renew, Recycle, Reuse** — (eg. reduce waste)

# How to build things

## Additive



## Subtractive

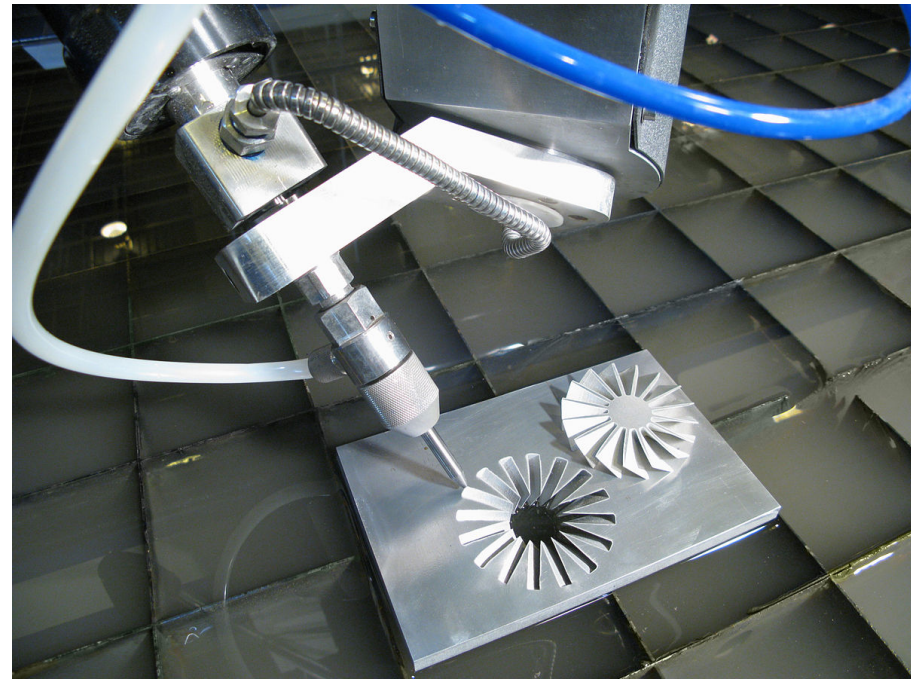


# How to build things

## Additive – 3D Printing



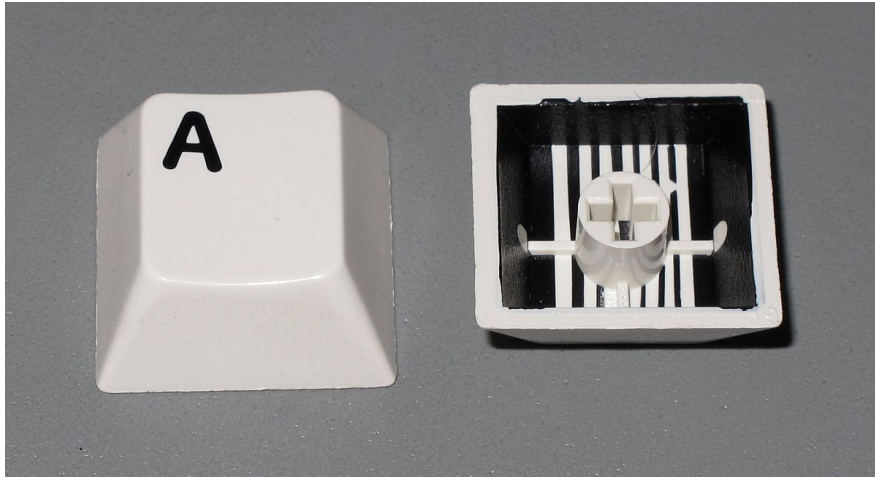
## Subtractive – “CNC” Computer Numerical Control



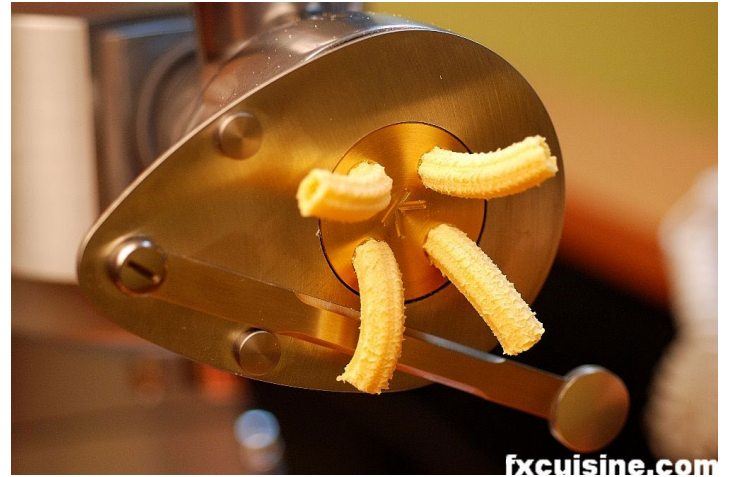


# How to build things

## Molded



## Extruded





# Two inventions that changed the world

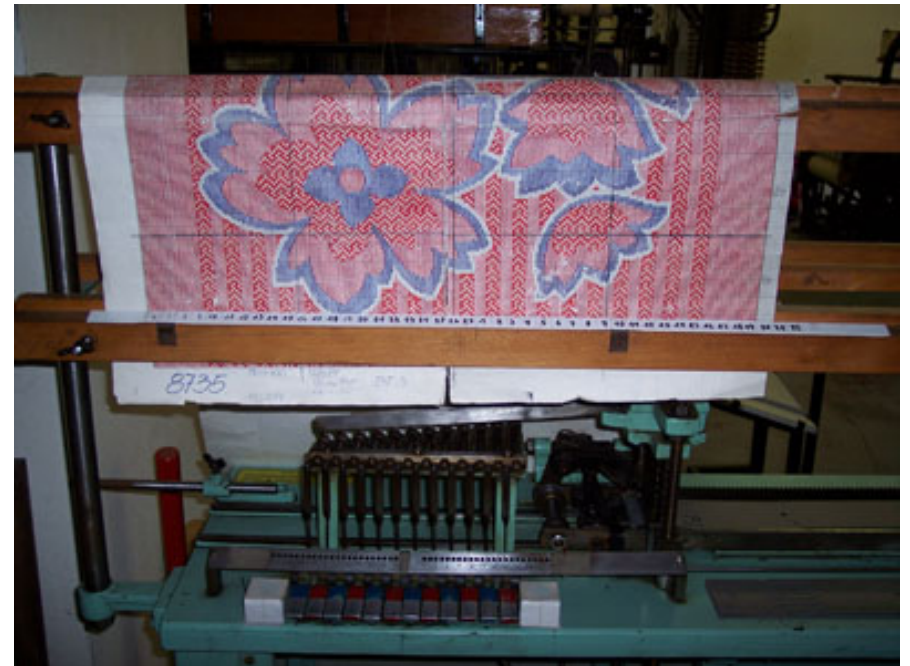
## Watt's Steam Engine



## Jaquard's Loom

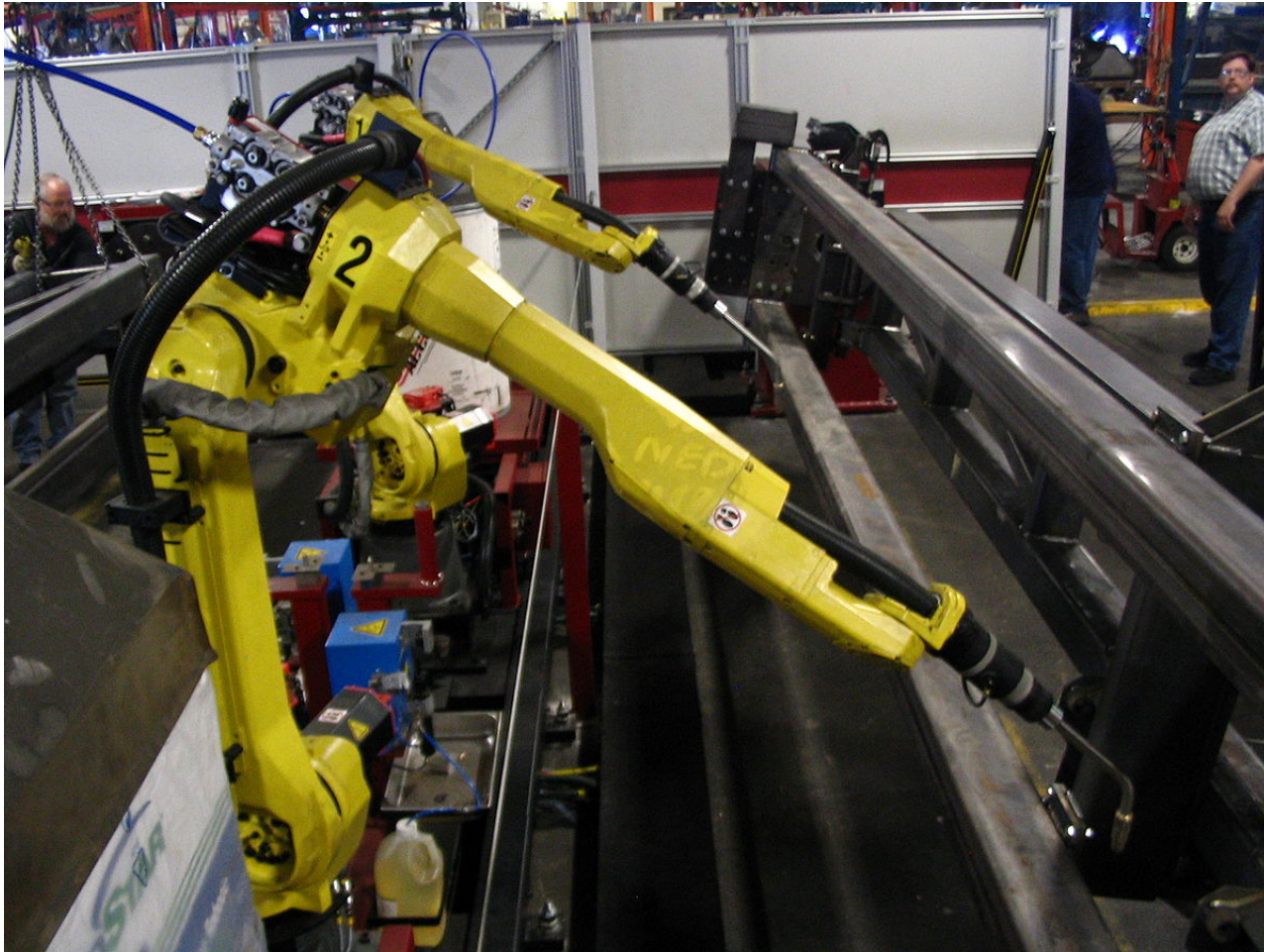


# Punch-card technology ...





...to automation!



# Energy of Manufacturing

**Table 3. Importance of location factors for location decisions from the perspective of all manufacturing companies.**

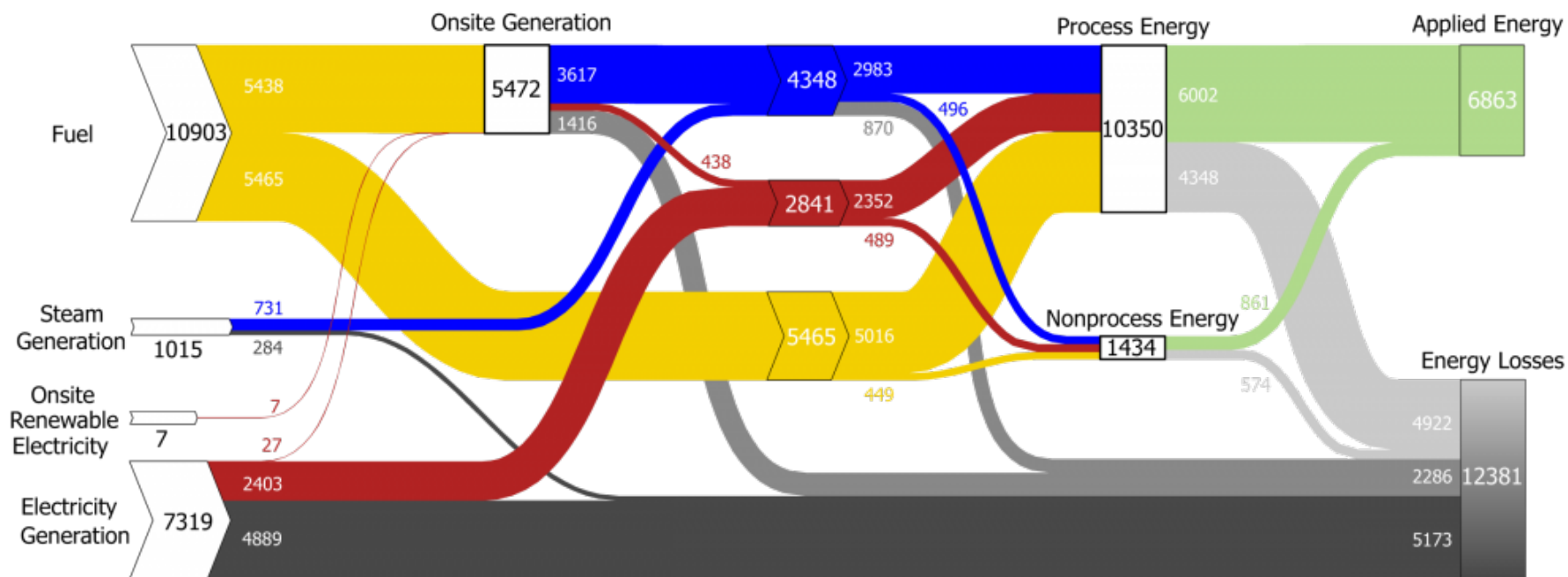
Driver	Score, 1–10
Talent-driven innovation*	9.22
Cost of labor and materials	7.67
Energy costs	7.31
Economic, trade, financial, and tax systems*	7.26
Infrastructure quality*	7.15
Investment in manufacturing and innovation*	6.62
Legal and regulatory system*	6.48
Supplier network	5.91
Local business dynamics	4.01
Health care*	1.81

*Source:* Data from Deloitte Manufacturing Competitiveness Index (Deloitte Council on Competitiveness 2010).

\* Factor is relatively movable through public policy, as opposed to broader market factors.

# Energy Use in the Manufacturing Sector

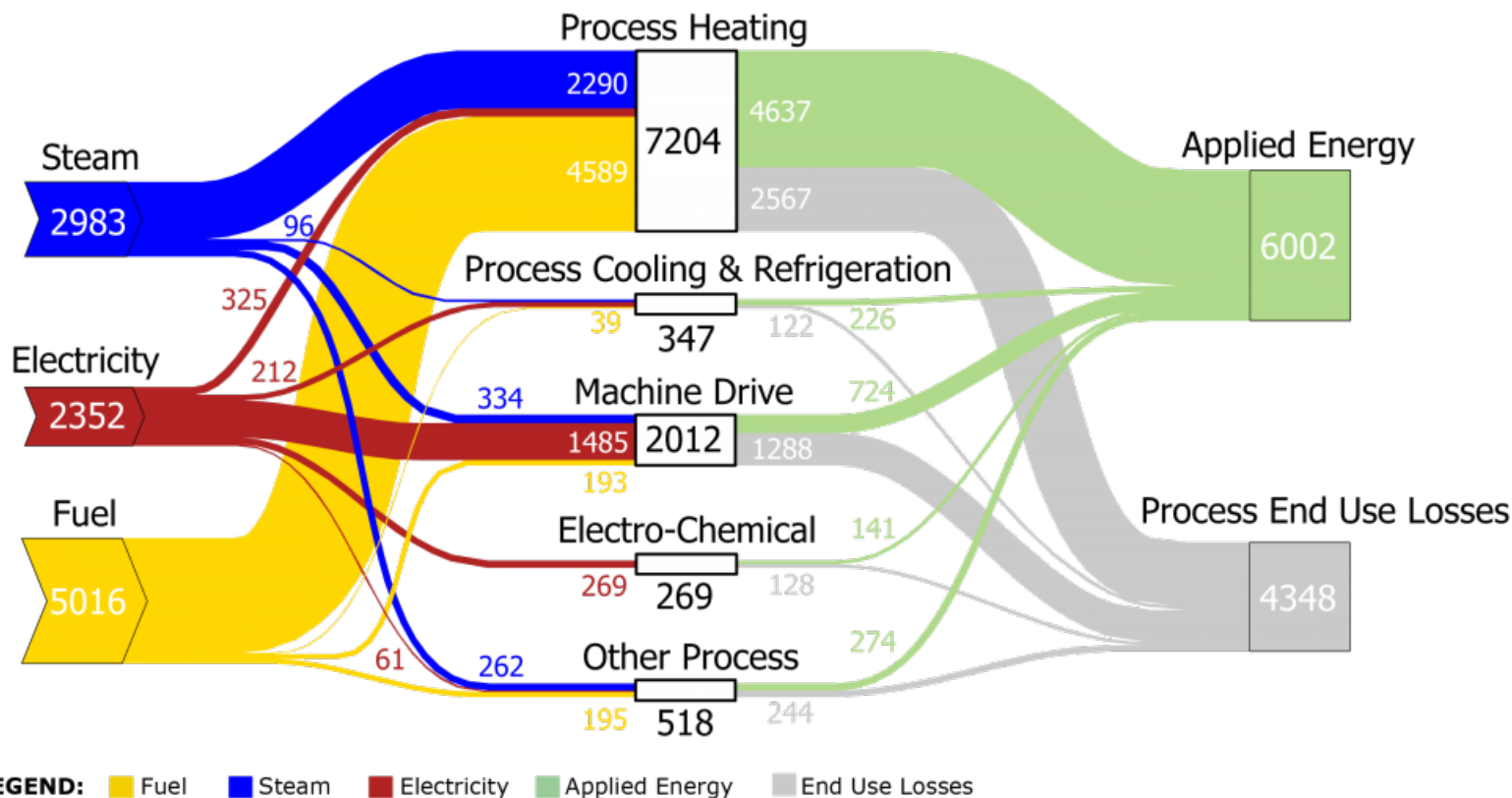
## U.S. Manufacturing Sector (TBtu), 2010



**LEGEND:** Fuel Steam Electricity Applied Energy Offsite Generation and Transmission Losses  
 Onsite Generation and Distribution Losses End Use Losses

# Process Energy in Manufacturing Sector

**Process Energy (TBtu), 2010**



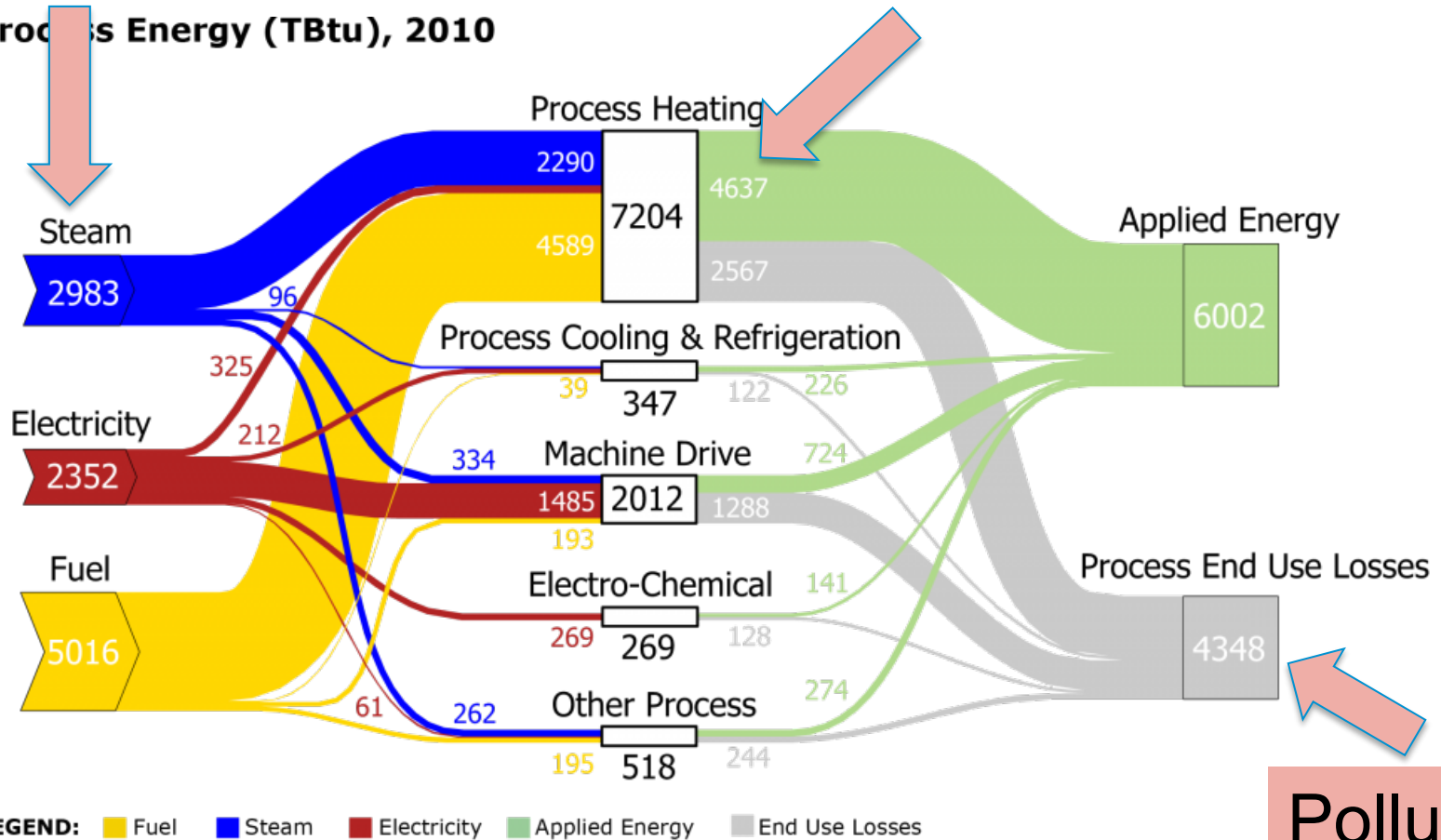


# Process Energy in Manufacturing Sector

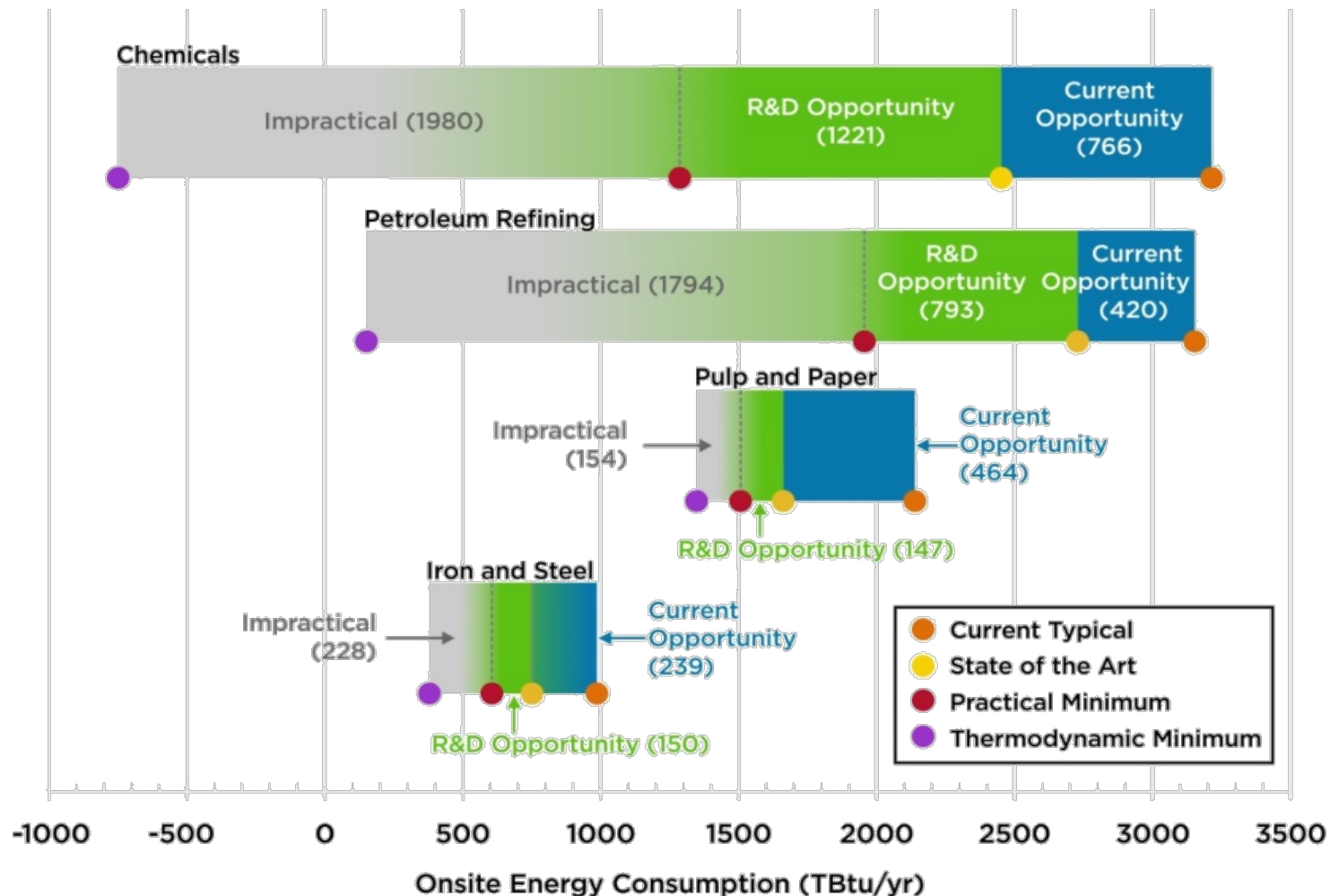
Source

Efficiency

Process Energy (TBtu), 2010

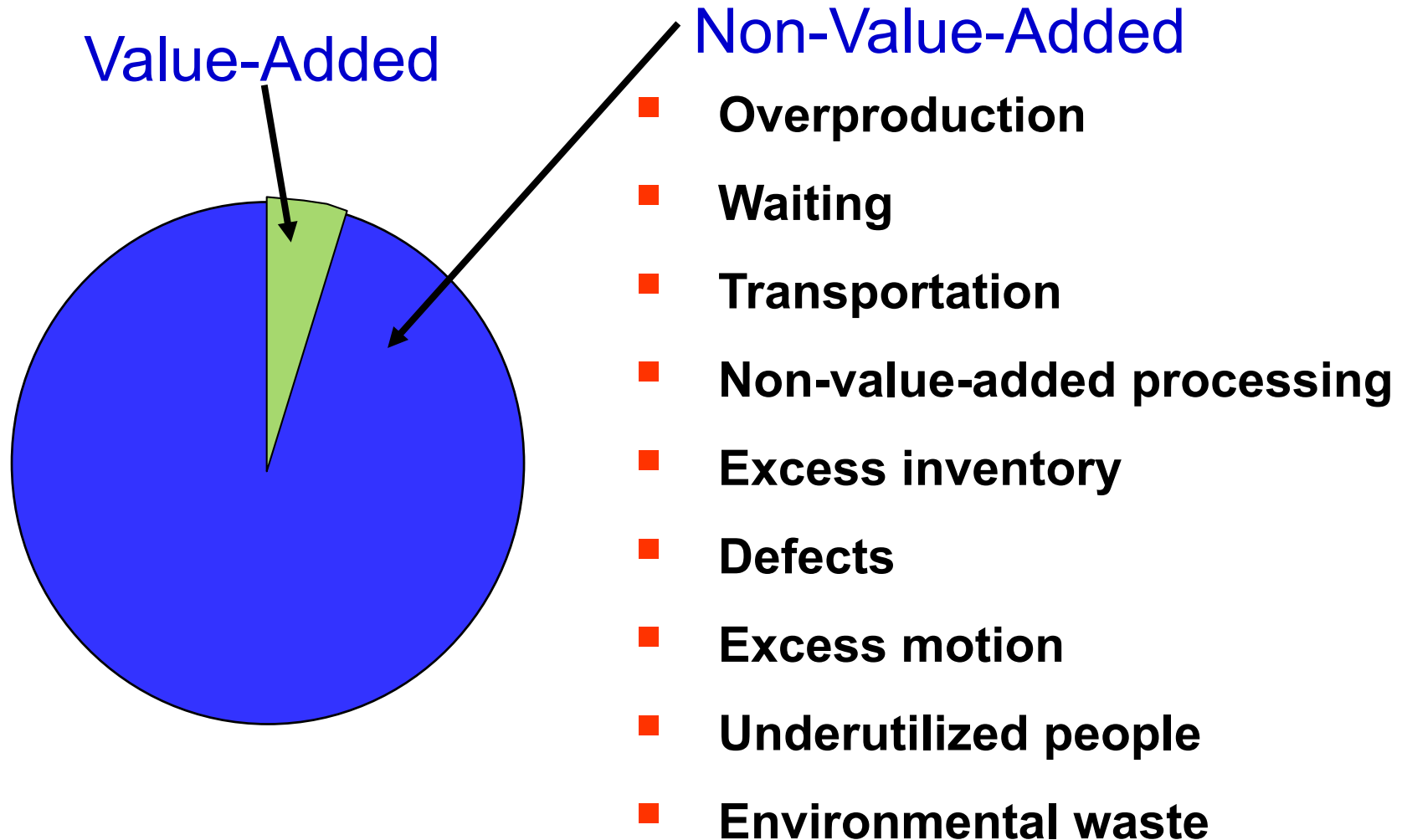


# Bandwidth Studies: Energy Savings Potentials



*Current opportunities represent energy savings that could be achieved by deploying the most energy-efficient commercial technologies available worldwide. R&D opportunities represent potential savings that could be attained through successful deployment of applied R&D technologies under development worldwide*

# Lean = Eliminating Waste



**Typically 95% of all lead time can be non-value-added.**

# What is Pollution Prevention (P2)?

Pollution prevention consists of any activity or strategy that

- eliminates or reduces the use of toxic substances;
- conserves water or energy; and/or,
- reduces (or better yet, eliminates) the generation of nonproductive output, hazardous waste, air emissions, wastewater, or other pollutants.

## Buzzwords Relating to P2

Zero-Waste

Source Reduction

Sustainability



# Material Use – Spray Efficiency

- Reassigned labor
- \$1400 in disposal
- 28,000 pounds overspray

- » Reduced variability from  $\pm 13$  lbs/unit to  $\pm 4$  lbs/unit (69%)
- » Reduced overspray
- » Stronger products (more resin on the product)



# Efficient Material Use Saves \$35k/year in

- landfill costs
- purchase volume of core panels



Requested supplier to provide  
different size stock



# Defects

Before



After



- Better ergonomics
- In-Line (reduced travel)
- Improved lighting
- Changes reduced cost of rework by \$208,000/yr

# Former Status Quo: Products Invented Here, And Made Elsewhere



# Why Was That?

- Lower labor cost – particularly important for labor intensive industries – and less labor hassle
- Sometimes lower energy costs
- Reduced environmental regulation and regulatory enforcement
- Outsourcing/off-shoring for business and product flexibility
- Other?

# But Change is Happening

Re-shoring/on-shoring because of:

- Lower energy prices
- Dissatisfaction with remote supply chain experience

New businesses and industries starting here because of:

- Great research universities and public and private labs
- National and local investment in R&D
- Improved political/governmental support climate for business investments

# So What is the Situation?

Manufacturing in the U.S. is changing

- Less labor dollar input per dollar value of output
  - Higher value materials
  - More work done by machines
- Increasingly requiring skilled technicians

But there are still a lot of old facilities, processes and equipment, with implications for:

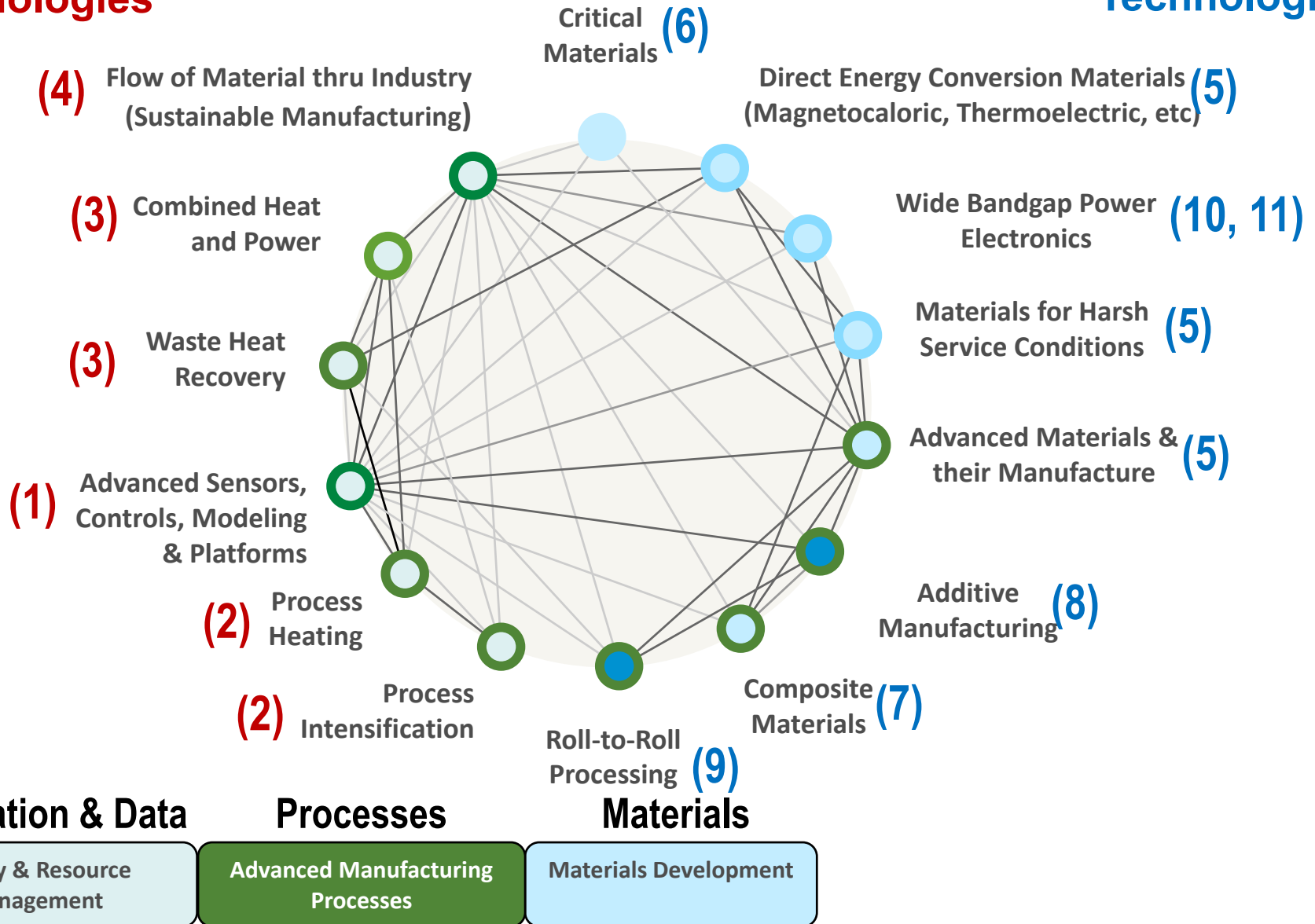
- Labor
- Capital
- Energy



# DOE QTR: Manufacturing Technology

## Efficiency Technologies

## Enabling Platform Technologies





# What Does Success Look Like?

**Products  
Invented Here...**



**...And Competitively Made  
Here!**

Break