Sustainable manufacturing: an introduction for tomorrow's engineer

MMAN 2130 – DESIGN AND MANUFACTURING

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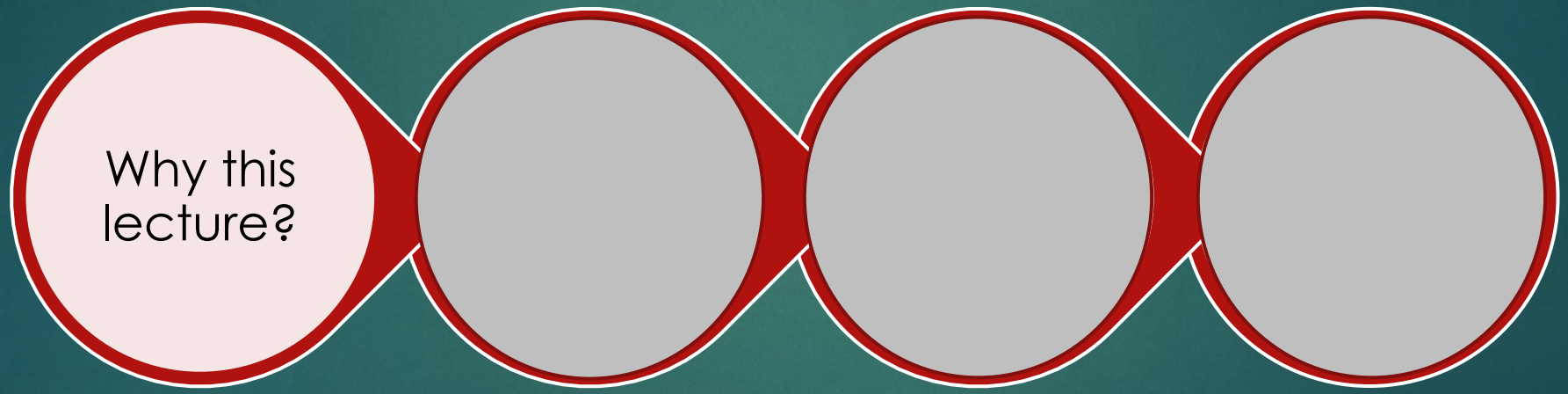
Agenda



SM = Sustainable Manufacturing

Why this lecture? (1/3)

CLIMATE CRISIS

If we want to survive as a species, we MUST keep average global temperatures below 2 degrees Celsius above pre-industrial levels (IPCC special report, 2018)

CO2 EMISSIONS FROM MANUFACTURING

20 % of total fuel combustion comes from manufacturing industries and construction (The World Bank, 2014)

Picture credits: The Conversation, ENFA Corporation

Why this lecture? (2/3)

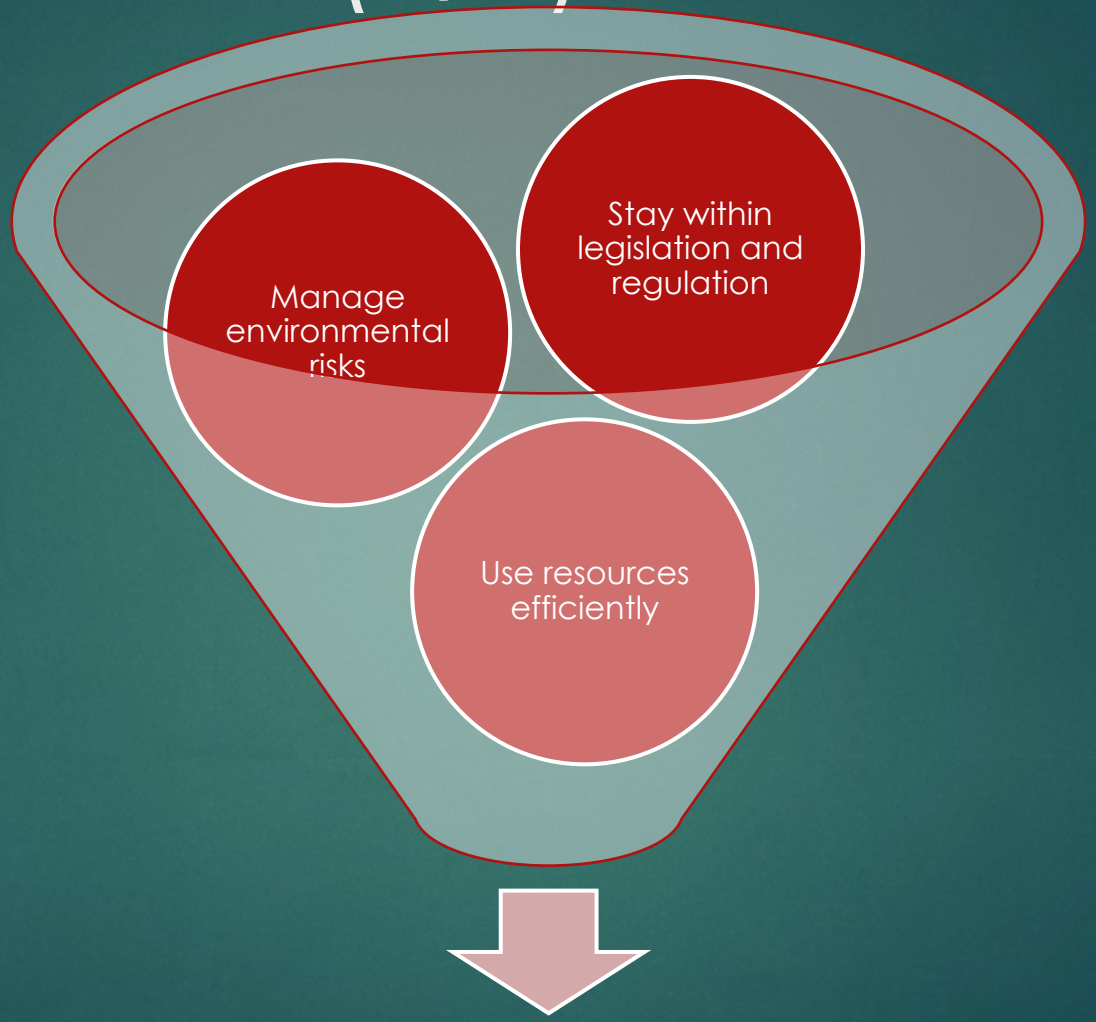
- Tougher regulations
- Increasing consumers awareness about environmental issues
- Trend: climate legislation.

Manufacturing companies are being held more and more accountable for wrong design choices and strategic choices that harm ecological systems.

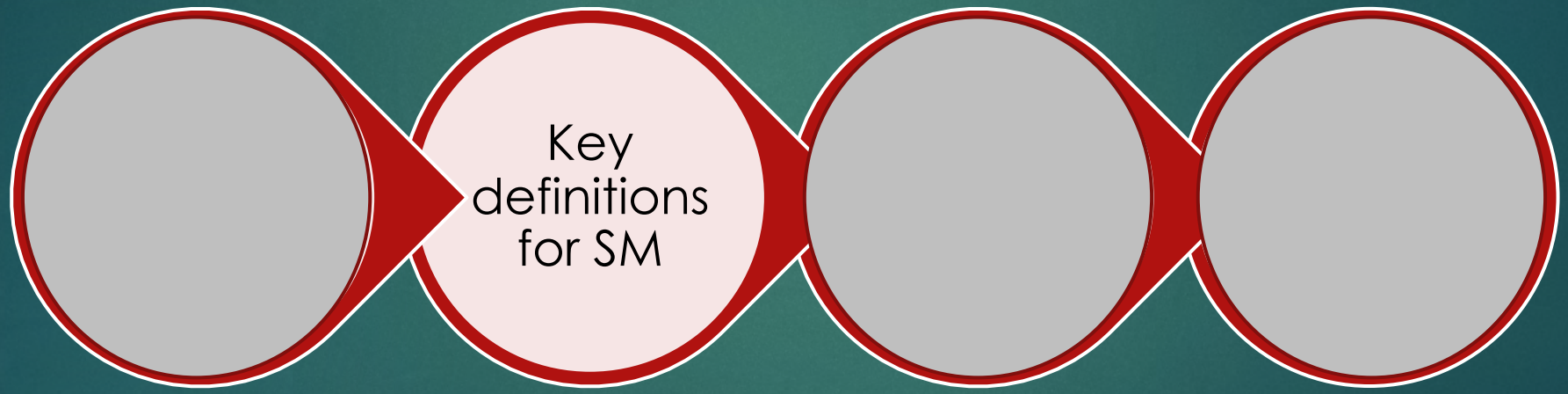
- We as engineers are in a unique and privileged position to design *better* products, services and production systems with respect to sustainable human and economic development. What does "better" mean?

Less waste, higher longevity/reusability/recyclability potential (circular economy) within resilient and transparent supply chains (industry 4.0)

Why this lecture? (3/3)



You have to consider all these factors as INPUT/CONSTRAINTS/VARIABLES in your design choices



SM = Sustainable Manufacturing

Sustainability

Please suggest a possible definition or some key words which would define it.

Cue: do not overthink

A general definition of sustainability

The quality of being able to continue over a period of time.

(Cambridge Dictionary)

The sustainability of the communities given the rate usage of scarce natural resources…

The sustainability of our business given future cash flow prospects…

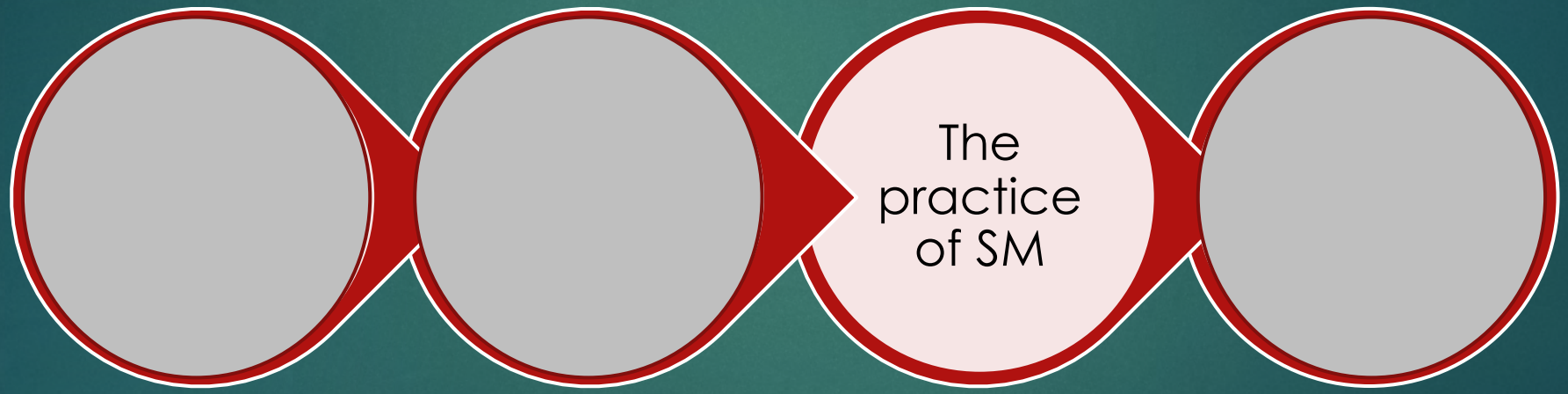
Sustainable manufacturing

With that understanding of “sustainability”, what then do we mean by “sustainable manufacturing”? What does that look like to you?

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."

U.S. Department of Commerce's Sustainable Manufacturing Initiative.



SM = Sustainable Manufacturing

The practice of sustainable manufacturing

- What if we could do more with less?
- Can you give me an example of opportunities you have spotted on a shop floor?

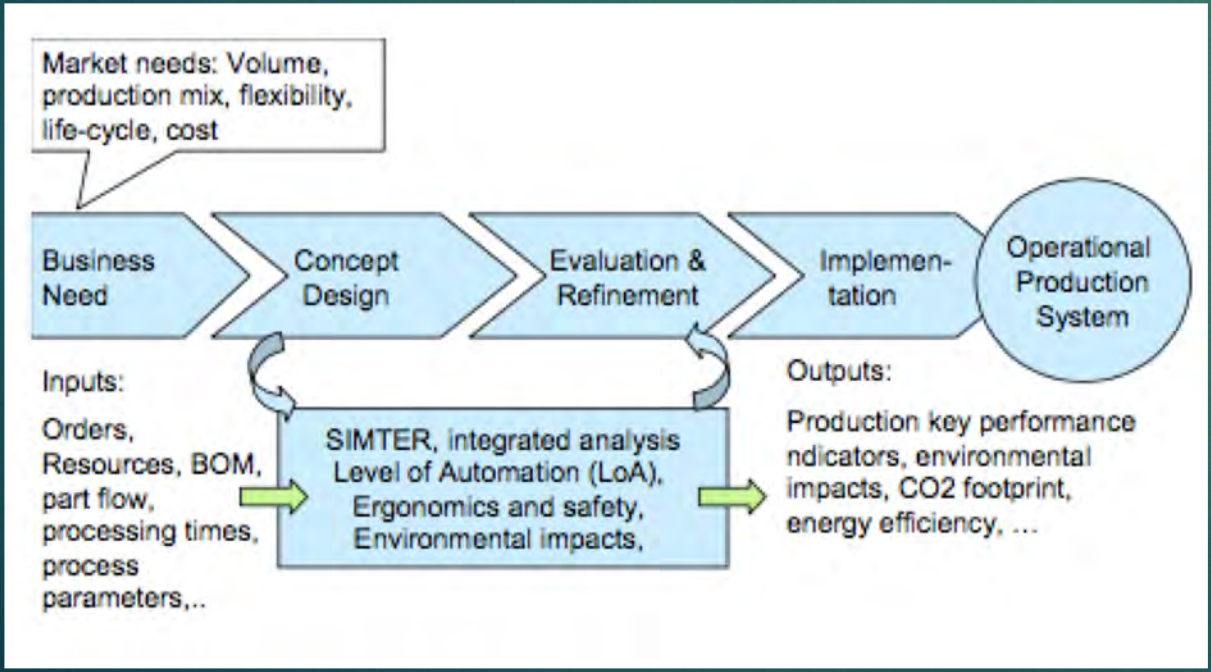
The origins of SM: eco-efficiency

- Eco-efficiency is a management strategy of doing more with less….It is based on the concept of creating more goods and services while using fewer resources and creating less waste and pollution (Glavič et al., 2012).
- Engineers spot opportunities for eco-efficient processes through the adoption of:
  - *Lean* tools and methods (e.g., Value Stream Mapping)
  - Life Cycle Assessment (LCA) of production processes (e.g., *carbon footprint* of a product)
  - **Factory simulation**: discrete event simulation (DES), machine learning (ML)
  - Much more

An example of factory simulation

- Application: sustainable manufacturing system design

Discrete Event Simulation (DES) through the ad-hoc developed tool "SIMTER", developed by Heilala et al (2008)



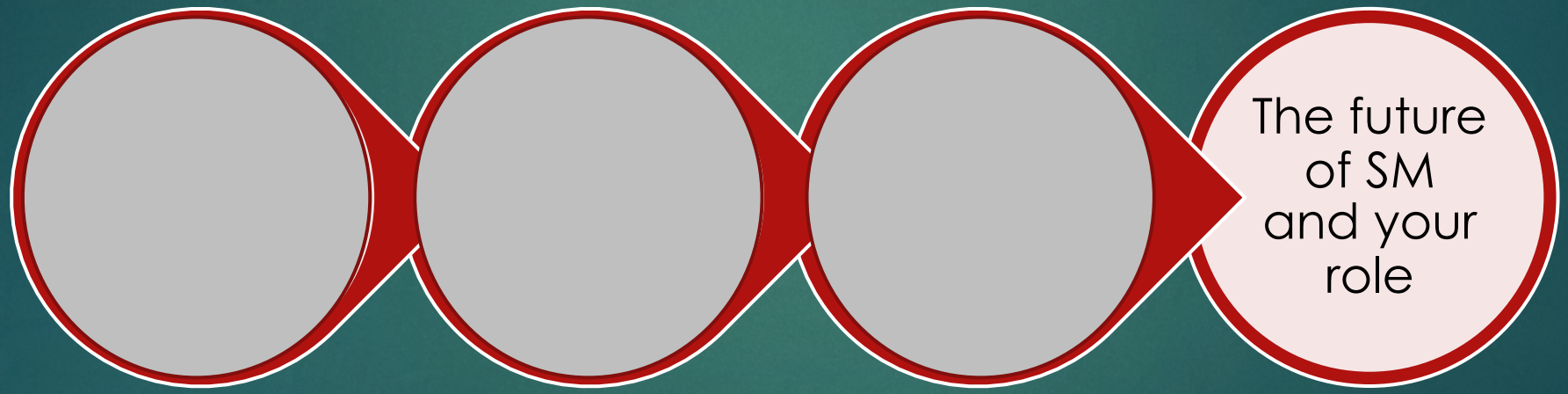
Variables:

- Level of automation
- Energy consumption, energy efficiency, CO_2 emissions, solid waste and hazardous waste

Is eco-efficiency a sufficient condition to realise sustainable manufacturing?

- No! Consider:
- Diminishing returns from continuous improvement initiatives on a "stable" system
- The risk of the burden (environmental, social) being shifted to other stages of the value chain that are not under the "jurisdiction" of the manufacturing company.

Example from a furniture factory: waste particle board recycled for the production of other "sustainable" products instead of waste avoidance (carbon sequestration from trees vs production of new products whose market demand is uncertain).



SM = Sustainable Manufacturing

What can I do as a production/manufacturing engineer working in a corporate environment?

- Listen to the inputs of sustainability professionals who work with you (environmental engineers, corporate sustainability professionals, etc.)
- Become a *budding* sustainability professional, on top of your manufacturing expertise

What can I do as a production/manufacturing engineer working in a corporate environment?

- Sustainability professionals should be able to make decisions that are *influential* for the future of the company. If you are not going to be a sustainability professional, listen to his/her input and include it in your design process.
- If hiring a consultant to perform an LCA analysis is too expensive for your company, you can still get the basics of the methodology through crash courses. User friendly software for LCA are popping up. You can perform a quick LCA yourself and make decisions about suppliers, materials, transports, etc.

Resources

- Practical: Sustainable Manufacturing Toolkit by OECD: https://www.oecd.org/innovation/green/toolkit/aboutsustainablemanufacturingandthetoolkit.htm

- Academic: An assessment framework for managing corporate sustainable manufacturing, by Ilaria Barletta: https://www.chalmers.se/en/departments/ims/news/Pages/An-Assessment-Framework-for-Managing-Corporate-Sustainable-Manufacturing-.aspx

Thank you for your attention