Sustainable Production: Energy and Resource Efficiency

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Different System Scale Levels



From the perspective of the organisation of the system, manufacturing activities, and related energy and resource improvement measures, can be considered as being composed of multiple levels:

Process Level: Individual device or machine tool in the manufacturing system, which is performing a unit process.

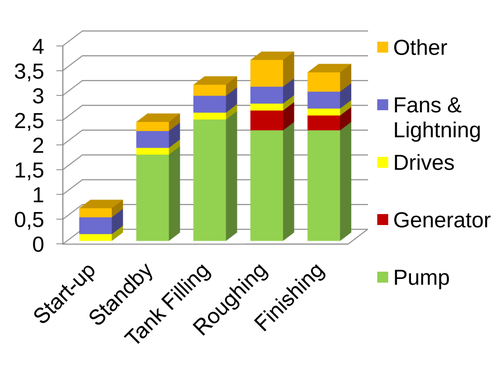
Multi-Machine Level: Logical organization of devices in the system that are acting in series or parallel to execute a specific activity.

Factory Level: Distinct physical entity housing multiple devices, which may or may not be logically organized into lines, cells, etc.

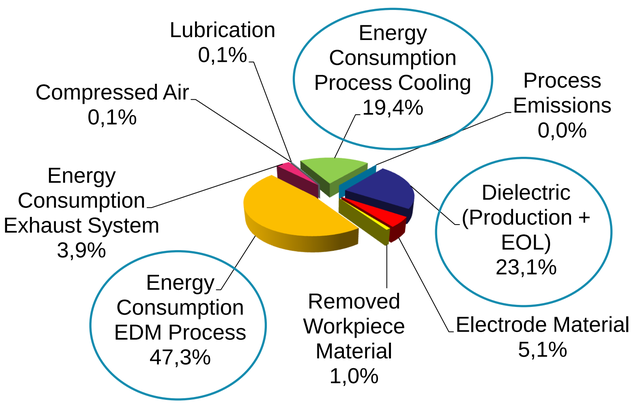
Multi-factory Level: Different facilities whose proximity to one another allows them to make use of possible synergies in terms of reuse of waste and lost energy streams.

Global Supply Chain: The entire manufacturing system, consisting of all the individual facilities, the infrastructure required to support the facilities, as well as the transportation and supply chain externalities.

Case study of Electrical Discharge Machining (EDM)



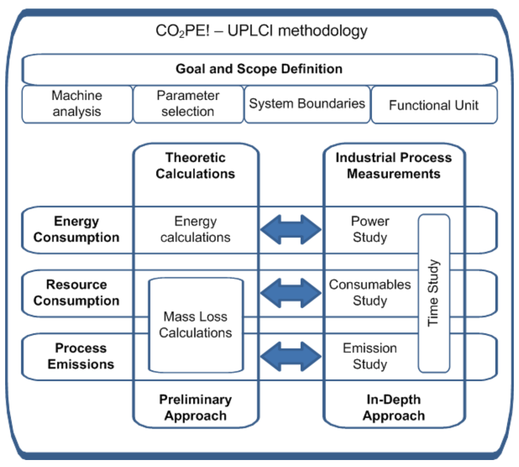
Power levels [kW] of EDM



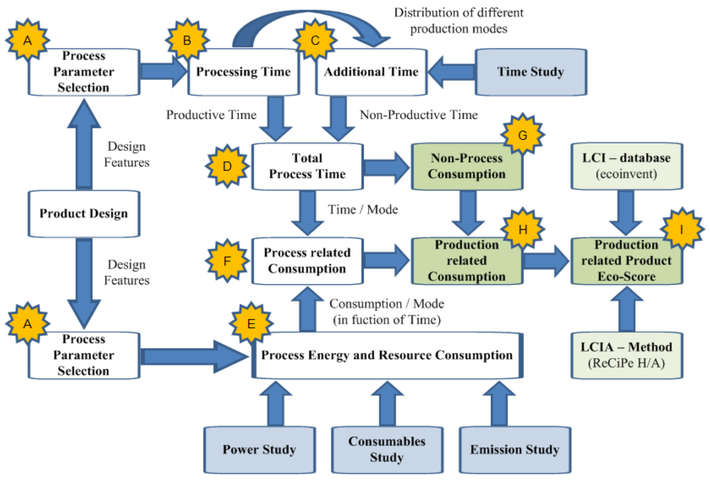
Impact assessment of 1hour of EDM roughing (copper electrode, hard metal workpiece)

Systematic Quantification of Environmental Impact of Unit Manufacturing Processes and Process Chains

In order to overcome the lack of as well as the significant spread of available data on the ecological performance of manufacturing processes, a systematic approach to collect and document Life Cycle Inventory (LCI) data has been developed. Besides a process LCI database, optimisation measures and ecodesign guidelines at machine tool level can be extracted using this methodology at subunit level. Furthermore, parametric process models allow to predict/determine the environmental footprint of the manufacturing stage based on the product design.



$CO_2PE!$ – UPLCI – Methodology



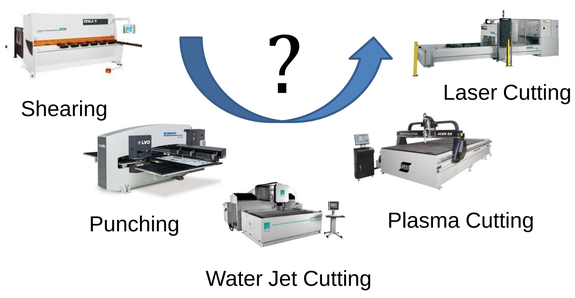
Schematic overview of parametric process models

Ecological Improvement of Manufacturing Unit Processes

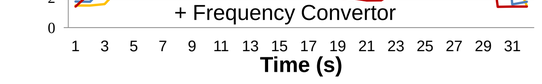
✓Optimized machine tool design
- ❖ More efficient machine tool components
- ❖ Technological changes (a)
- ❖ Waste recovery within a machine tool
- ❖ Integrated or central peripherals

✓Optimized process control
- ❖ Selective actuation of non-continuously required devices
- ❖ Reducing idle production times
- ❖ Optimized process parameters (b)
- ❖ Energy and resource efficient process modelling and planning

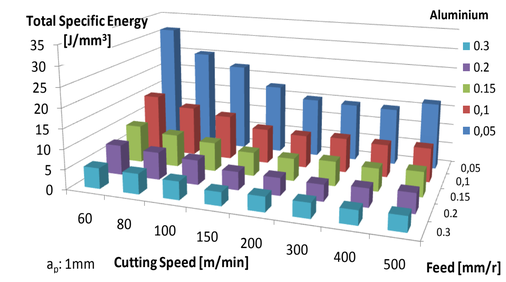
✓Effects of process selection
- ❖ Process selection (c)
- ❖ Optimal machine tool capacity (d)
- ❖ Optimal resource consumption



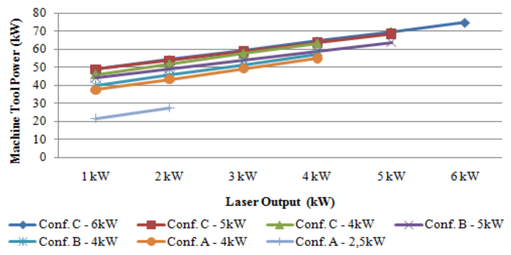
c) Process selection based on environmental criteria



a) Power consumption for air bending processes



b) Specific energy consumption as a function of cutting parameters for turning processes



d) Power consumption as a function of laser power for laser cutting processes

$CO_2PE!$ – Initiative
Cooperative Effort on Process Emissions in Manufacturing

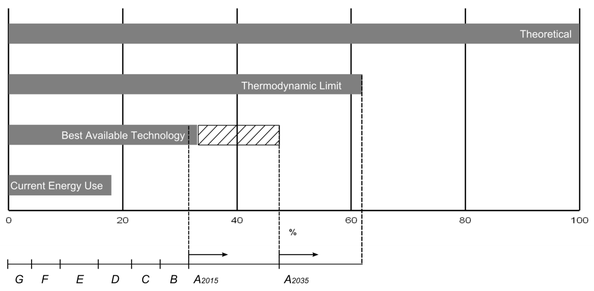
As the wide variety of available and emerging manufacturing processes cannot be handled by a single effort, the $CO_2PE!$ UPLCI initiative has been launched in 2009. The main objective of the initiative is to coordinate international efforts aiming to document and analyze the overall environmental impact for the major part of the full process taxonomy.

Currently, the initiative has 28 research partners around the world and is operating in a CIRP EREE Collaborative Working-Group and recognized by the UNEP-SETAC Life Cycle Initiative and as an IMS Manufacturing Technology Platform (MTP) Theme.



$CO_2PE!$ – website and data exchange tool
http://www.co2pe.org

Impetus towards Eco-Labelling of Machine Tools



Efficiency classes based on the relative value of BAT to the thermodynamic limit efficiency

In order to convey the environmental performance information of machine tools from manufacturers to users, a uniform way of reporting and/or labelling is required. In this aspect, efficiency classes based on the relative value of the best available technologies (BAT) to the thermodynamic limit efficiency are proposed. However, the specific characteristics of machine tools (e.g. capacity, accuracy...) have to be thoroughly considered in the development of a standardized methodology and implementation of an eco-label.

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