# Application of decision making to assure sustainable design and manufacturing


***Getasew TADDESE*, Prof. Emmanuel DUC**, Dr. Severine DURIEUX*****

*****Université Clermont Auvergne, CNRS, SIGMA Clermont, Institut Pascal, F-63000 Clermont–Ferrand, France***

****School of Mechanical & Industrial Engineering, Addis Ababa University, P.O.BOX 385, Addis Ababa, Ethiopia***

**Ecole doctorale Sciences Pour l'Ingénieur**


# Introduction

Sustainable design and manufacturing is a complex system where various performance indicators must be considered to fully achieve it. Industries such as aerospace, automotive and health, are facing challenges of balancing priorities between economic, environmental and social factors. So far, various researchers tried to address sustainability aspect of traditional manufacturing processes and design aspect by developing frameworks and strategies, but none were comprehensive in addressing all dimensions of sustainability. An increased awareness of people in considering impacts of product on the environment (pollution and resource consumption on the ecosystem), human health (safety and risk) and value (durability, less maintenance and high performing product with minimized overall cost) is currently compelling industries to seek for assuring sustainability by taking balanced consideration of all dimensions to keep them highly competent and reputable in the current market system.

Thus, this study identifies complete list of decision variables and performance indicators for additive manufacturing (AM) and propose a comprehensive multicriteria decision making framework to fully address sustainability during the design and manufacturing of a part. Furthermore, proper validation and implementation is required after identifying performance indicators and possible interactions between them. Through this whole process, modular (energy/material/cost) models will also be adapted and developed which can independently be utilized for partial evaluation as required by users or industries.

# Methods

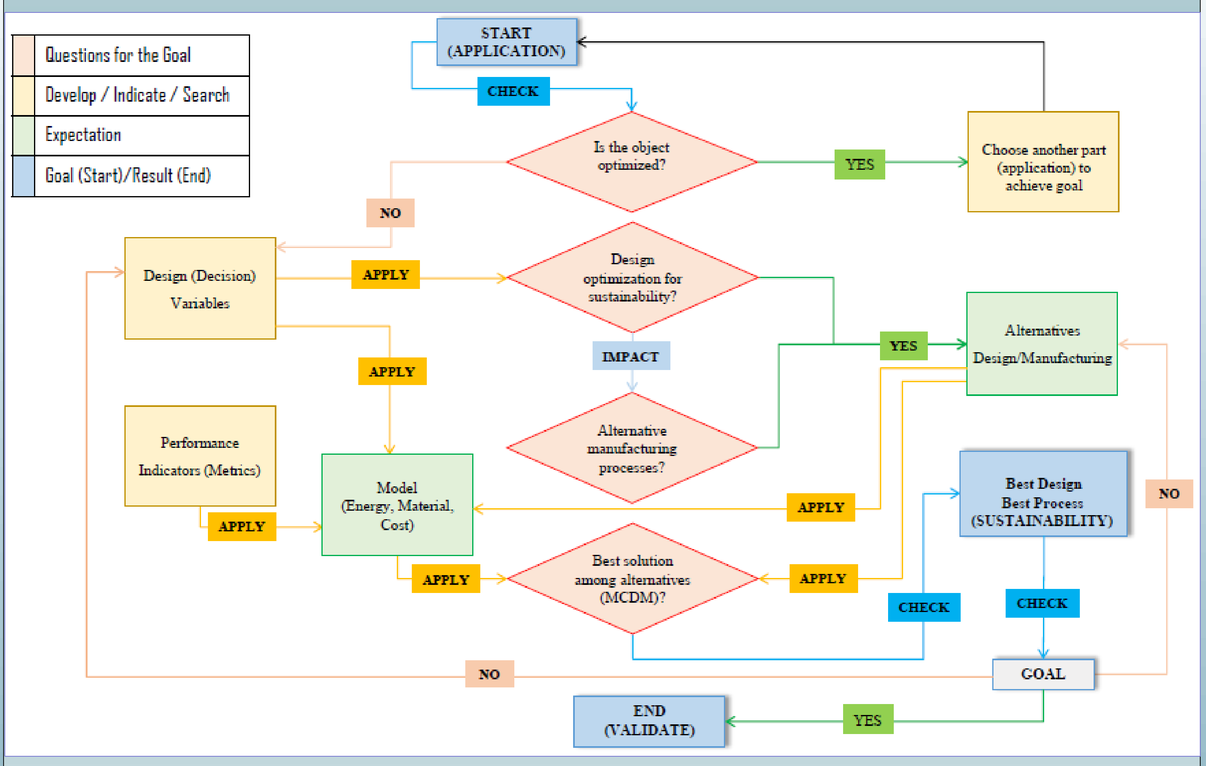


**Figure 1: General framework**

## *Simplified outline of the methodology:*

- Identify and evaluate existing and proposed AM process.
- Description of the new AM solution using set of decision variables.
- Identify set of performance indicators according to functionality and sustainable manufacturing.
- Propose a comparison methodology.
- Modeling of the Additive Manufacturing Process.
- Analyze sustainability based on the identified Performance Indicators.
- Compare sets of new AM solutions with the existing solutions.
- Application: validation of the solution using a part from a real industry application (aerospace or automotive)

# Results (expected)

***The expected major results of the study are:***

- Identification and development of complete list of decision variables and performance indicators (sample indicated in Fig. 2).
- Develop a comprehensive MCDA tool for AM processes towards assuring sustainable manufacturing.
- Modeling of possible alternatives formed from each of the PI's listed on the fourth row.
- A MCDA to select the best alternative among models.

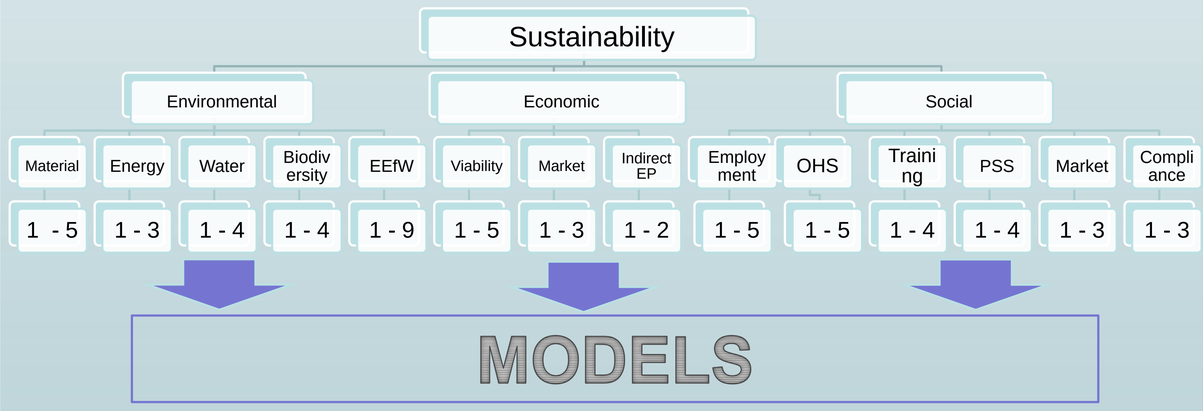


**Figure 2: MCDA framework (Sample)**

## *Remark:*

Additional row as row 5 (not indicated on the figure 2) will contain possible alternatives which are utilized by researchers to develop models.

# Conclusions (expected)

- Additive Manufacturing as new way to improve sustainability performance of part and process.
- Role and impact of additive manufacturing for sustainability of design and manufacturing of high value products.
- A new frame work for assuring sustainability during the design and manufacturing of part which considered complete list of performance indicators for all dimensions of sustainability.

# Bibliography (selected)


Ahmad, S., Wong, K.Y., Tseng, M.L., Wong, W.P., 2018. Sustainable product design and development: A review of tools, applications and research prospects. Resour. Conserv. Recycl. 132, 49–61. https://doi.org/10.1016/j.resconrec.2018.01.020

Haapala, K.R., Zhao, F., Camelio, J., Sutherland, J.W., Skerlos, S.J., Dornfeld, D.A., Jawahir, I.S., Clarens, A.F., Rickli, J.L., 2013. A review of engineering research in sustainable manufacturing. J. Manuf. Sci. Eng. 135, 041013

Jin, M., Tang, R., Ji, Y., Liu, F., Gao, L., Huisingh, D., 2017. Impact of advanced manufacturing on sustainability: An overview of the special volume on advanced manufacturing for sustainability and low fossil carbon emissions. J. Clean. Prod. 161, 69–74. https://doi.org/10.1016/j.jclepro.2017.05.101.

Shao, G., Brodsky, A., Shin, S.-J., Kim, D.B., 2017. Decision guidance methodology for sustainable manufacturing using process analytics formalism. J. Intell. Manuf. 28, 455–472. https://doi.org/10.1007/s10845-014-0995-3

Sossou, G., Demoly, F., Montavon, G., Gomes, S., 2018. An additive manufacturing oriented design approach to mechanical assemblies. J. Comput. Des. Eng. 5, 3–18. https://doi.org/10.1016/j.jcde.2017.11.005

Yuan, C., Zhai, Q., Dornfeld, D., 2012. A three dimensional system approach for environmentally sustainable manufacturing. CIRP Ann. 61, 39–42. https://doi.org/10.1016/j.cirp.2012.03.105


## *About Getasew TADDESE:*

He is a senior Lecturer at the School of Mechanical and Industrial Engineering, Addis Ababa University, Ethiopia. He got BSc degree in Mechanical Engineering from Mekelle University in Ethiopia and MSc degree in Materials Engineering and Nanotechnology from Politecnico di Milano, Italy and double MSc degrees in Environmental Assessment and Integrated Management from L'Istituto Universitario di Studi Superiori di Pavia, Italy and Tongji University, Shanghai, China.

Currently, he is working on his first year PhD study at Sigma Clermont as a result of collaboration established as Ethio-France PhD program between the Ethiopian Ministry of Education, the French Embassy in Addis Ababa and Campus France.