

Masthead Logo

Wayne State University

ROEU 2018-19

Research Opportunities for Engineering
Undergraduates (ROEU) Program

1-1-2019

An Energy Profile Model for Fused Deposition Modeling 3D Printing Process

Calvin Hawkins

Opportunity and Significance

- Develop a strategy to monitor & estimate the energy consumption of FDM additive manufacturing
- Benefits to manufacturers and designers to design and manufacture products with minimal energy consumption

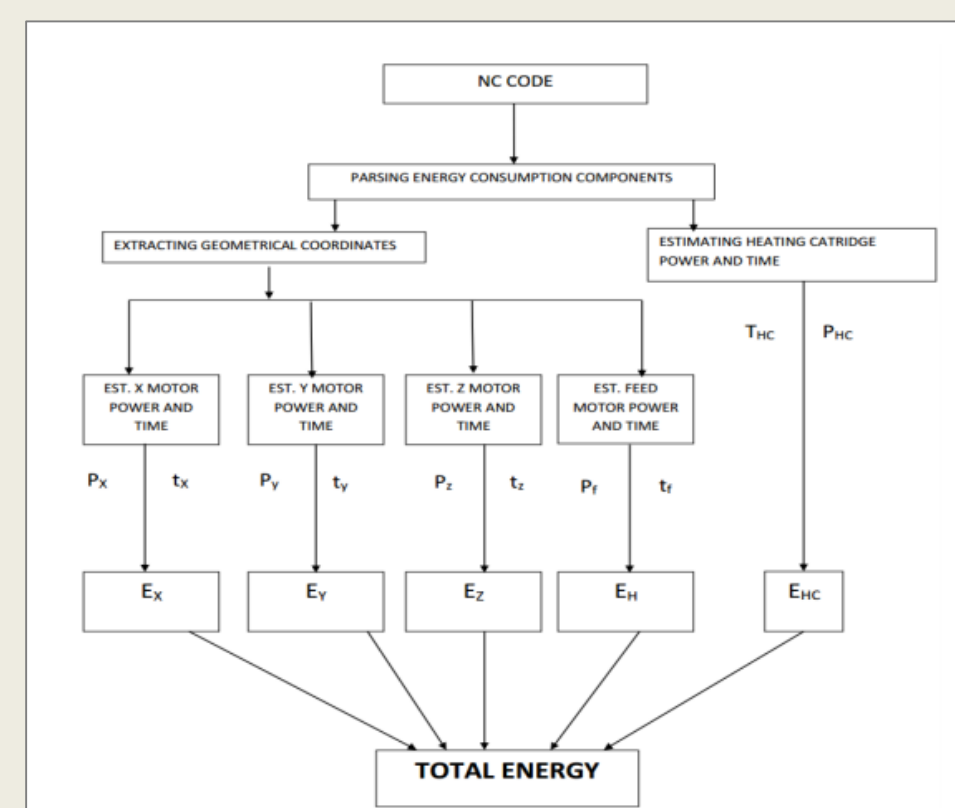
Technical Objectives

- Link the energy consumption of FDM prints to individual components
- Develop a power meter that allows for analyzing specific components in a FDM 3D printer
- Develop a method to visualize energy consumption of a print

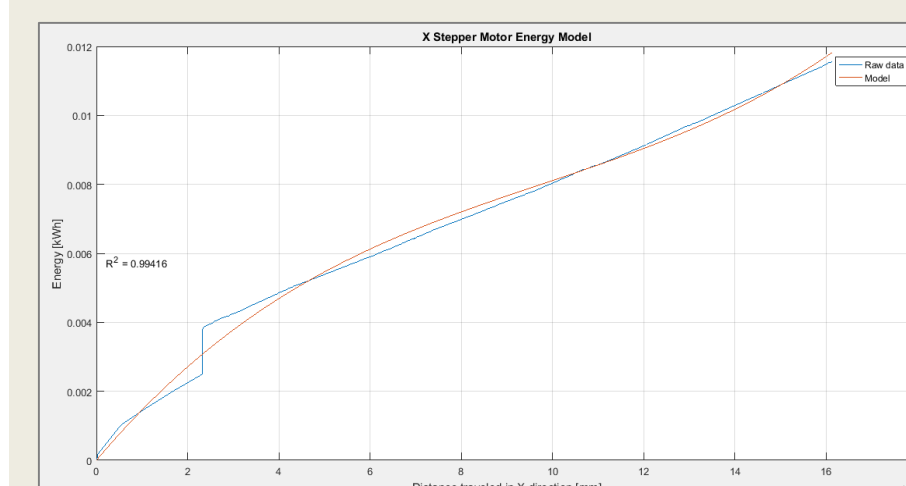
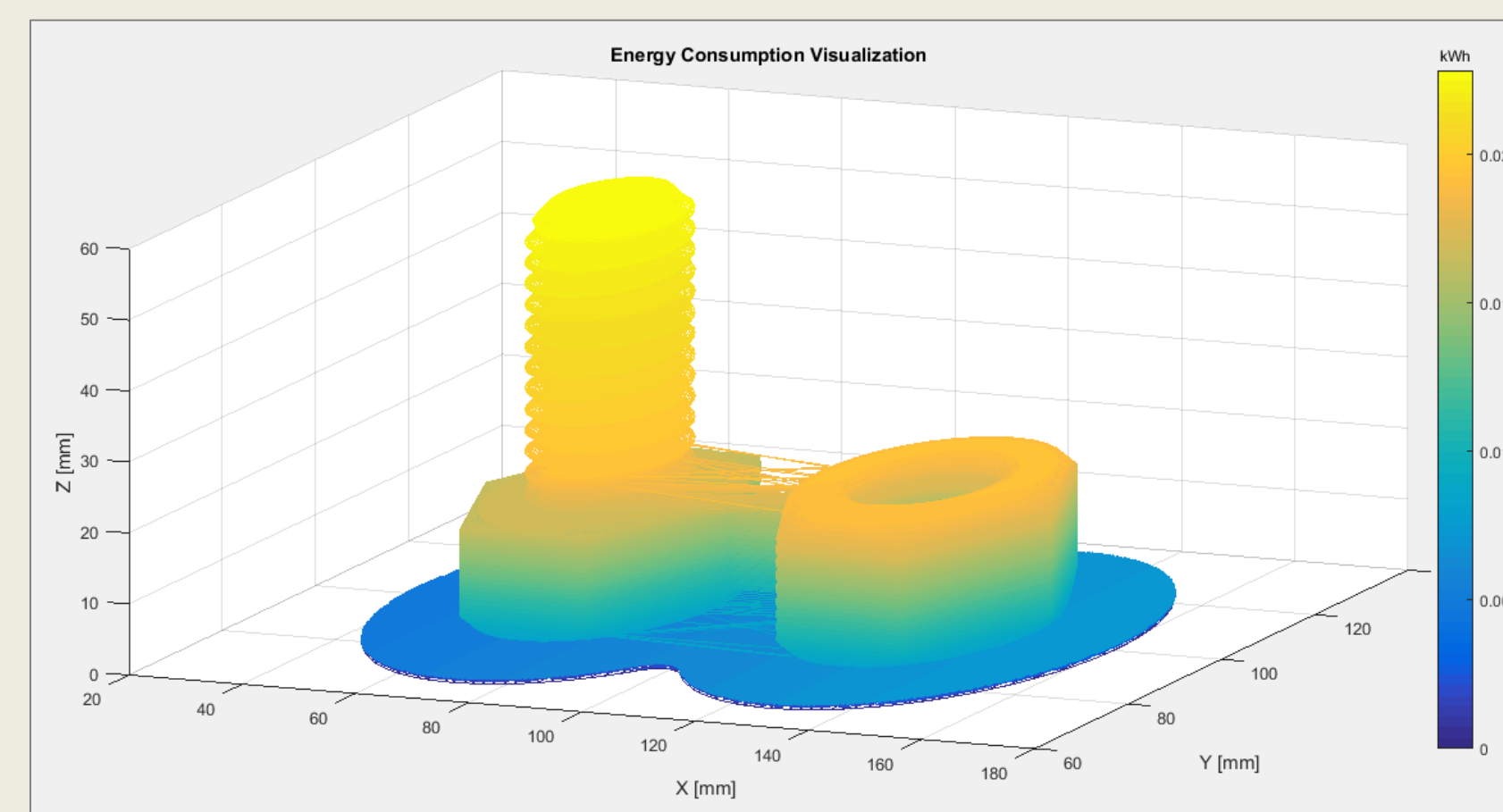
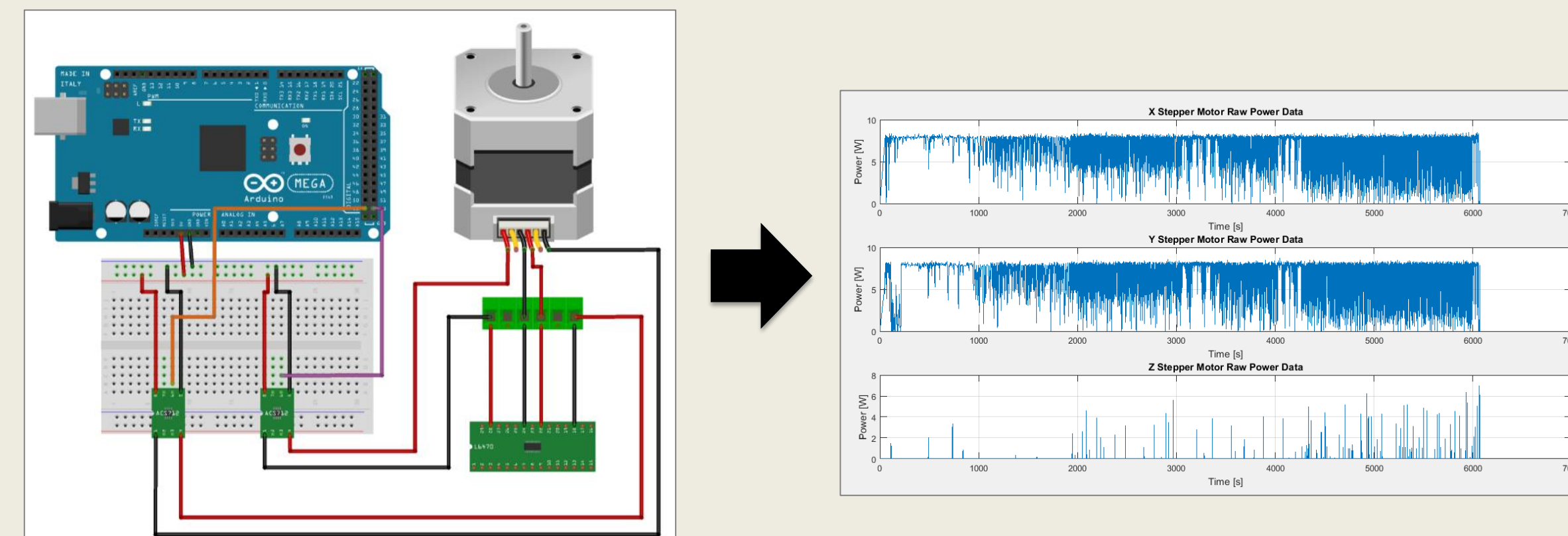
Related Work and State of Practice

- Previously, an Energy Model has been developed:

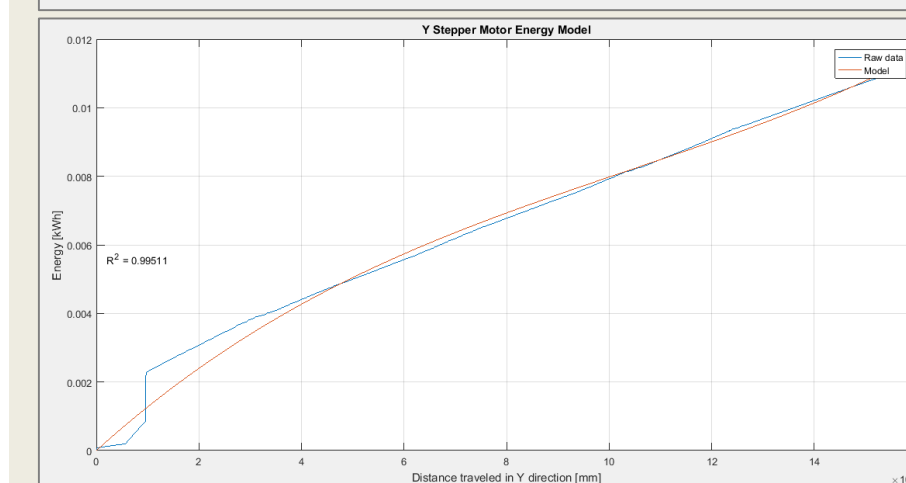
$$E_{tot} = \int P_x * dt_x + \int P_y * dt_y + \int P_f * dt_f + E(\theta) + E_{const.}$$



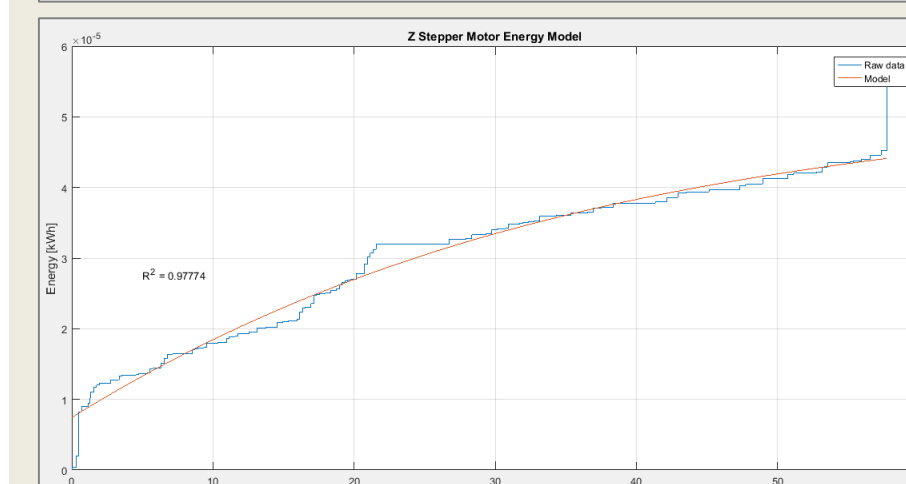
Technical Approach, Accomplishments, and Results



$$E_x = (3.91 \times 10^{-18}) * x^3 - (1.15 \times 10^{-12}) * x^2 + (1.57 \times 10^{-7}) * x + 6.42 \times 10^{-12}$$



$$E_y = (2.64 \times 10^{-18}) * y^3 - (8.19 \times 10^{-13}) * y^2 + (1.35 \times 10^{-7}) * y + 5.48 \times 10^{-12}$$



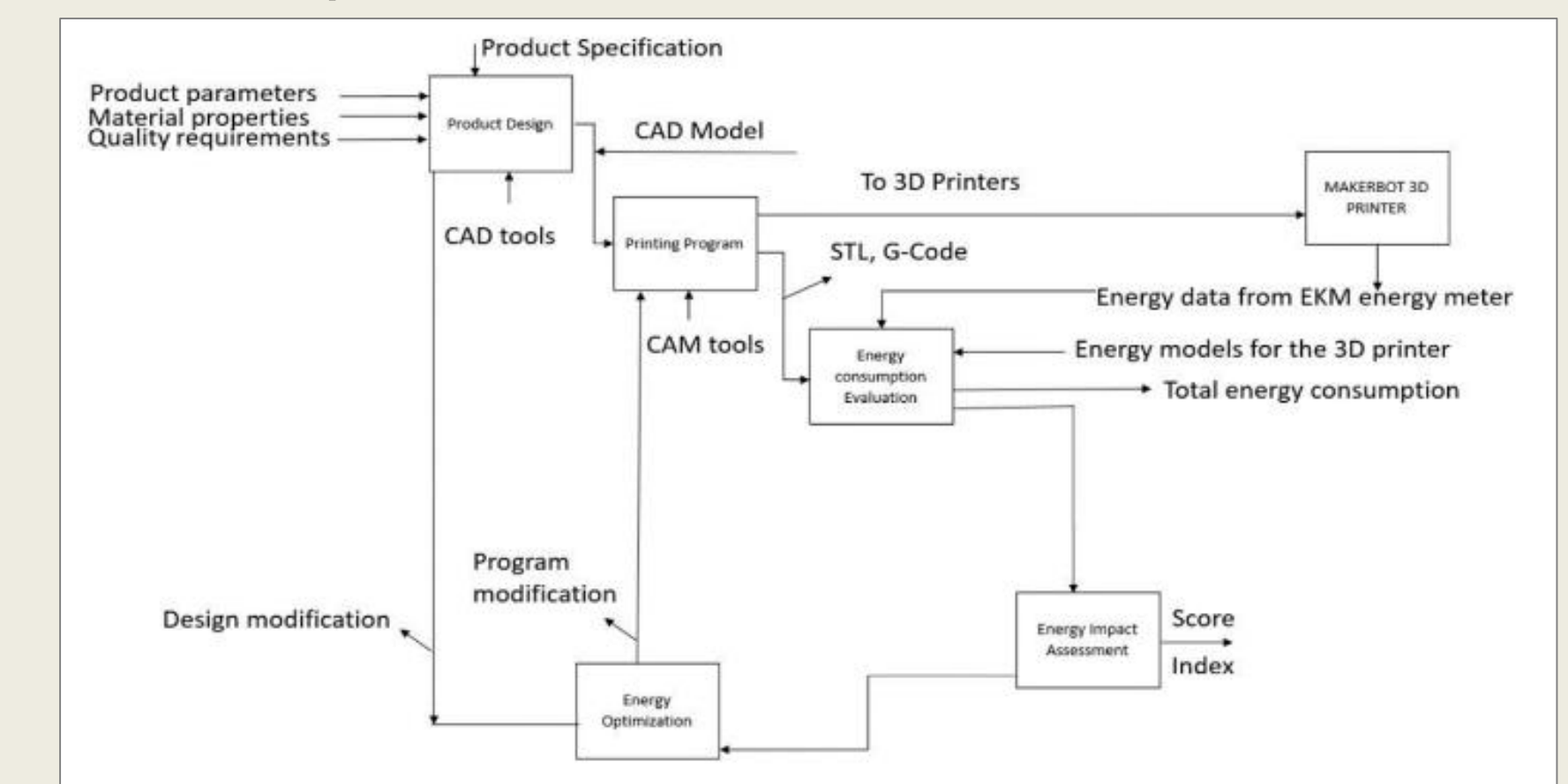
$$E_z = (6.79 \times 10^{-11}) * z^3 - (1.43 \times 10^{-8}) * z^2 + (1.24 \times 10^{-6}) * z + 7.45 \times 10^{-6}$$

Next Steps for Development and Test

- Use the Arduino based power meter to monitor the power consumption of the printer's heating element, and feed motor
- Update the algorithm to use the g-code to estimate total energy consumption rather than just the motors used for motion

Commercialization Plan & Partners

- Integrate the energy consumption visualization into 3D printing slicing software
- This work was performed within Wayne State's NSF I/UCRC Center for e-Design
- Potential to optimize design to minimize energy consumption:



References

Waterman, N. A. and P, Dickens. 1994. Rapid product development in the USA, Europe and Japan, World class design to manufacture 1, 27-36

Upcraft, S. & R, Fletcher., The rapid prototyping technologies. Assembly Automation, 23, 318-330.

David Dornfeld, Lee Clemon, Aditya Krishna, Anton Sudradjat, Maribel Jaquez and Marwan Rammah. 2013, "Precision and Energy Usage for additive manufacturing". Laboratory of Manufacturing and sustainability(LMAS)