



Life Cycle Analysis of Terrestrial vs. In-Space Incremental Forming

Grace Burcaw

Environmental Engineering, University of New Hampshire, Durham, NH 03824



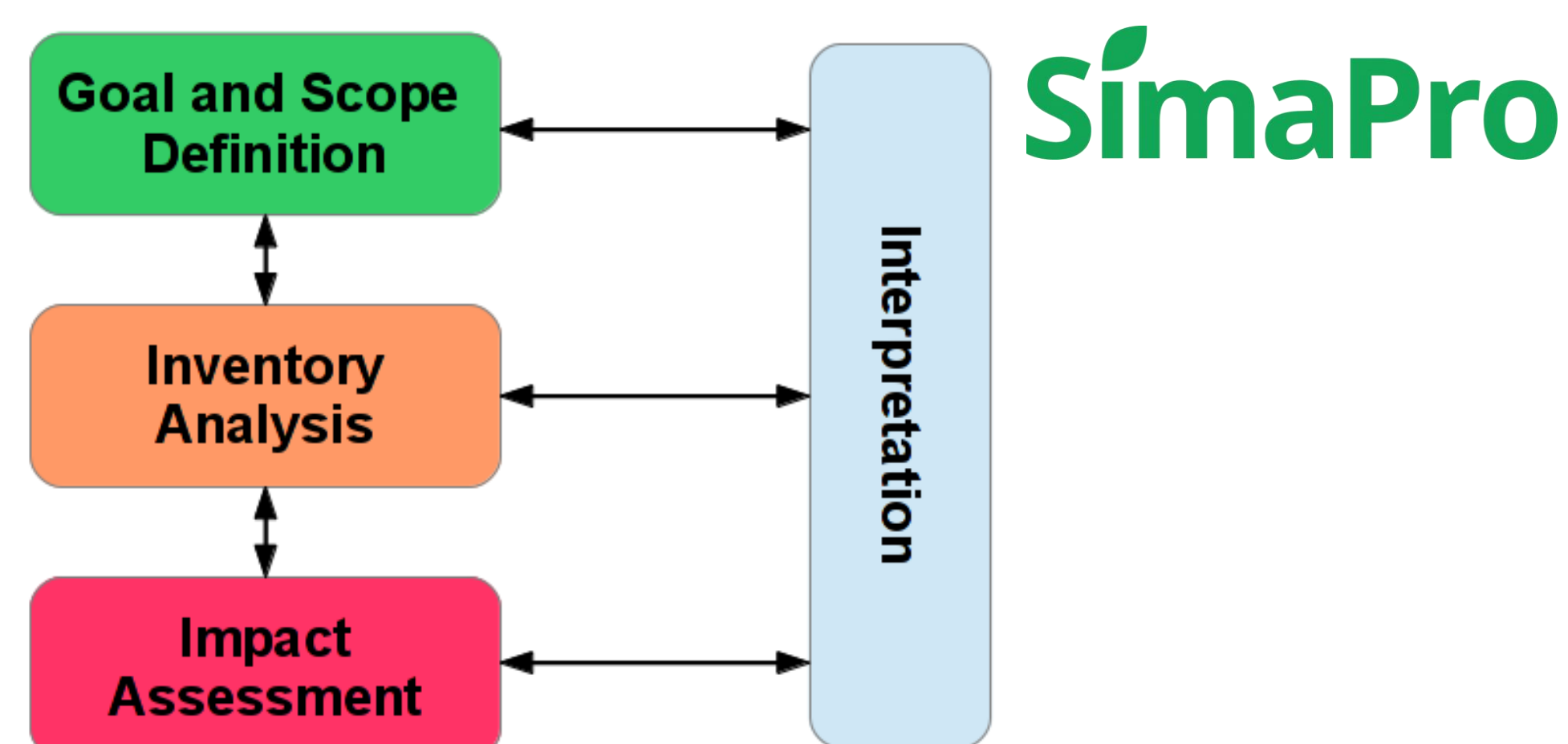
Introduction

Project Goal: The goal of this project is to compare the environmental impacts of incremental forming for terrestrial vs. in-space manufacturing.

Life Cycle Analysis (LCA)

- Tool to measure the environmental impact of human processes
- Accounts for all stages of a products life, including upstream and primary energy - **cradle to grave**
- Used to compare environmental tradeoffs to pick most sustainable solution

Methodology

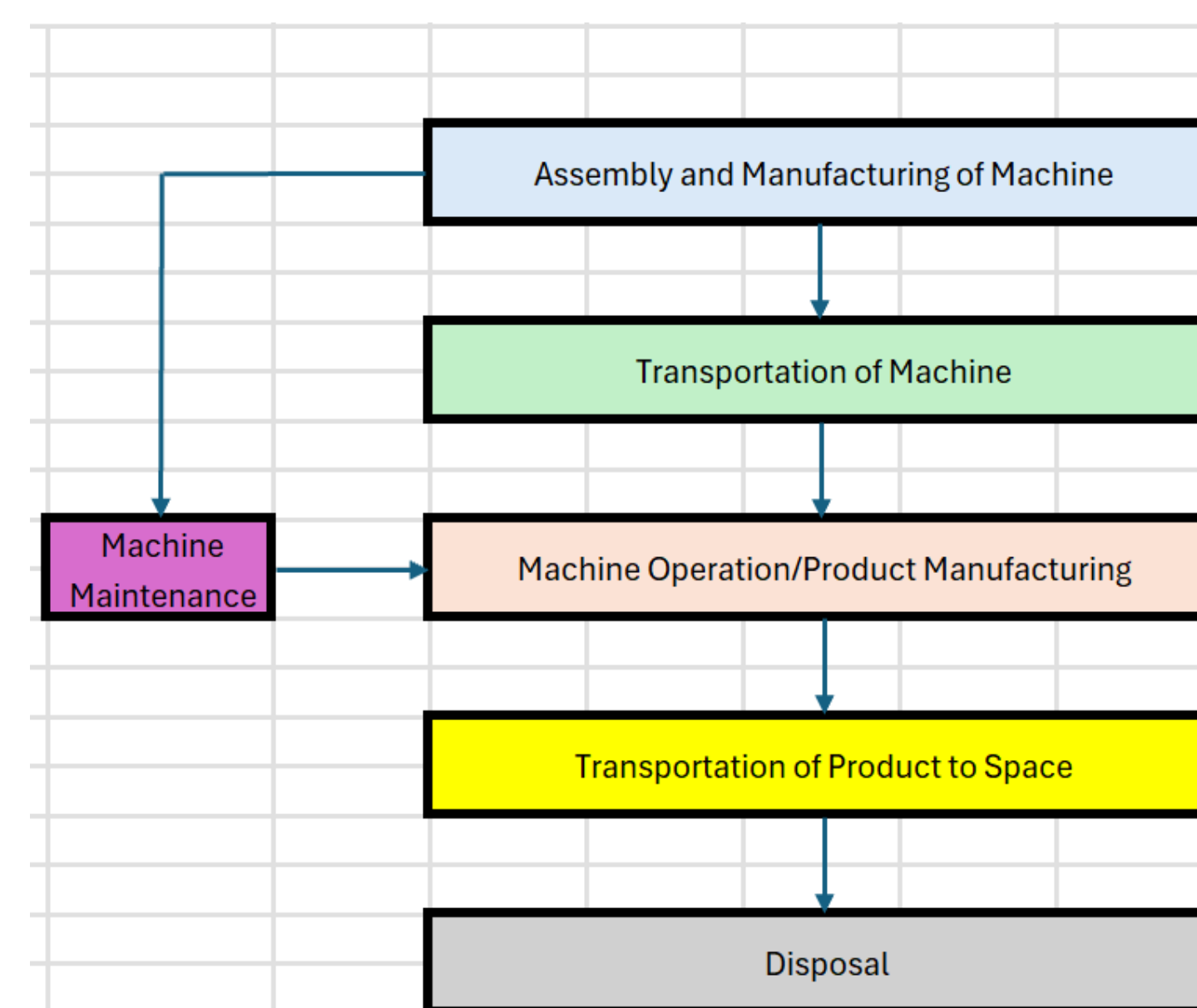


Key equipment

- Double Sided Incremental Forming Machine at John Olson Manufacturing Center
- SimaPro Life Cycle Analysis Software
- Excel

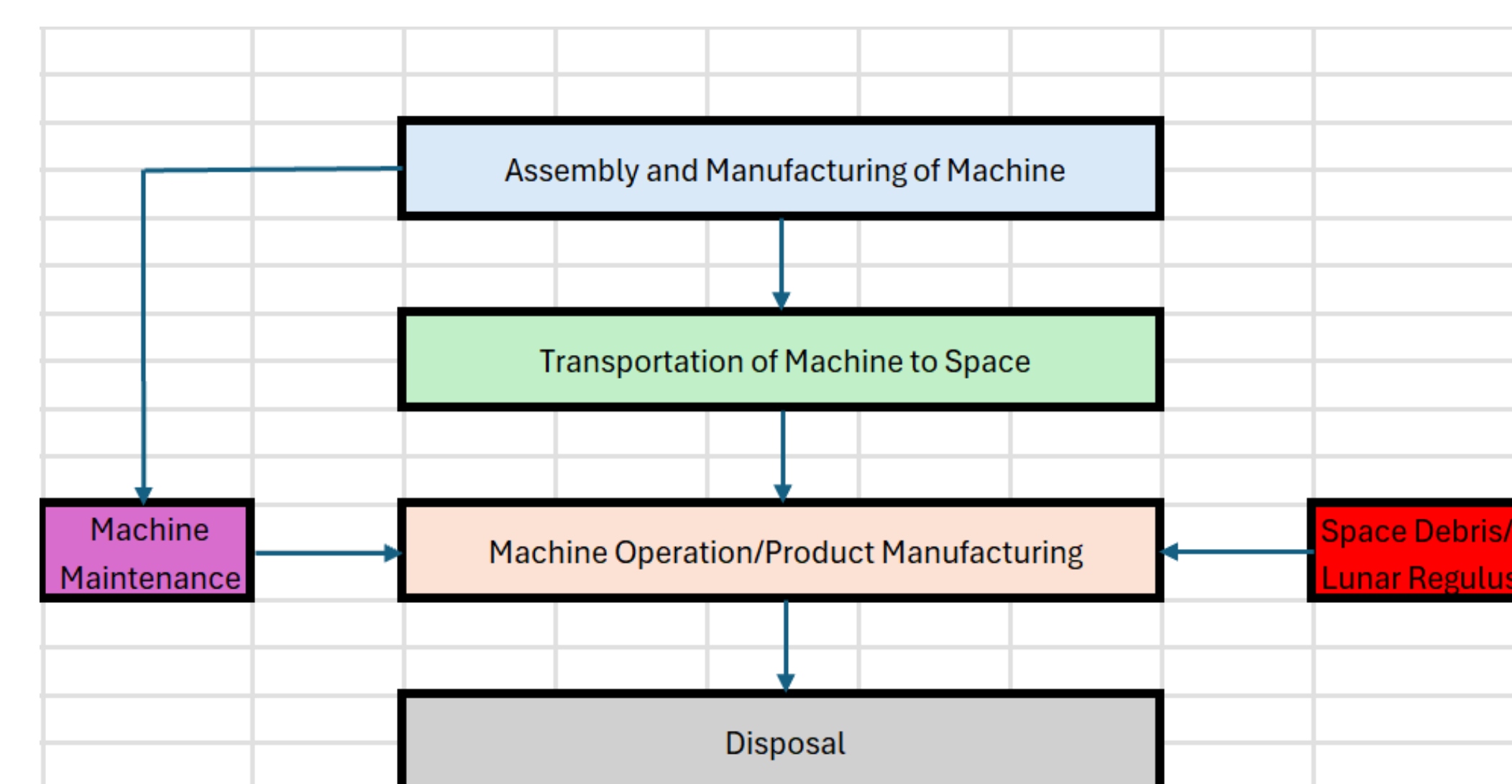
Life Cycle Flowcharts

Terrestrial



Life Cycle Phase for Terrestrial Manufacturing

In-Space



Life Cycle Phase for In-Space Manufacturing

Life Cycle Inventories

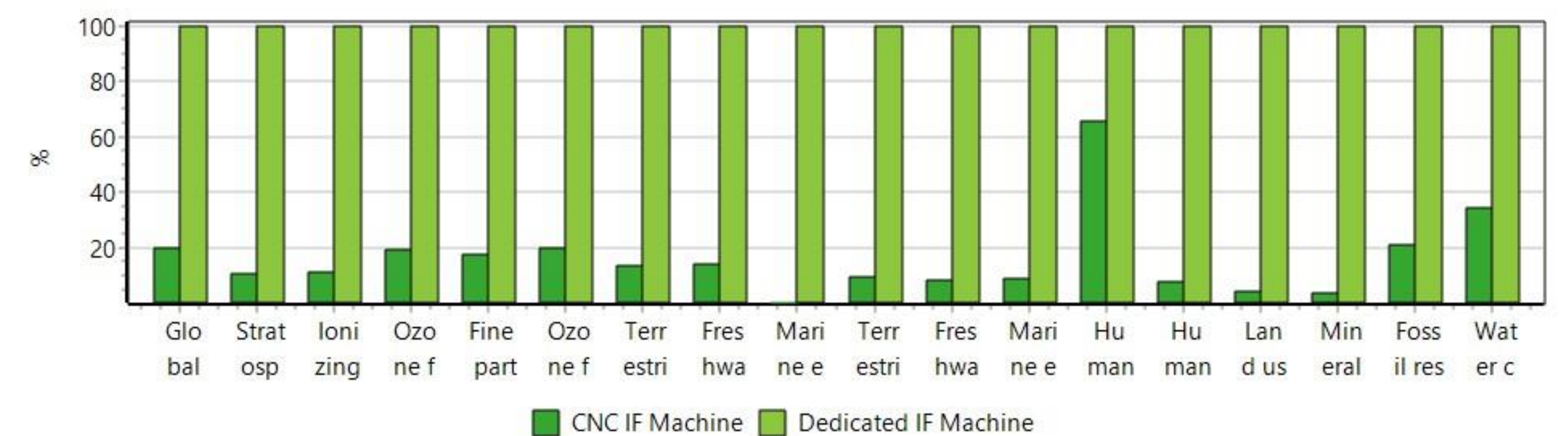
CNC Incremental Forming Machine Inventory

Material	Value	Units	Input on SimaPro	Comments
Sheet Metal	0.44276	kg		
3-Axis CNC Machine				
Solid Forming Tool	0.28123	kg	Steel, low-alloyed (GLI) market for steel, low-alloyed Cut-off, S	High speed steel (HSS)
Forming die				
Column v4	1.9129	kg	Steel, low-alloyed (GLI) market for steel, low-alloyed Cut-off, S	Mild steel
Lower plate	4.5373	kg	Steel, low-alloyed (GLI) market for steel, low-alloyed Cut-off, S	Mild steel
Dynamometer base	9.0748	kg	Steel, low-alloyed (GLI) market for steel, low-alloyed Cut-off, S	Mild steel
Clamping plate	1.099	kg	Steel, low-alloyed (GLI) market for steel, low-alloyed Cut-off, S	Mild steel
	0.05008	kg	Steel, low-alloyed (GLI) market for steel, low-alloyed Cut-off, S	Screws
Backing plate	3.9331	kg	Steel, low-alloyed (GLI) market for steel, low-alloyed Cut-off, S	Mild steel
Dynamometer	2.24	kg	Steel, low-alloyed (GLI) market for steel, low-alloyed Cut-off, S	Assumed 7.3 metal to plastic ratio
	0.96	kg	Polycarbonate (GLI) market for polycarbonate Cut-off, S	Plastic
	0.01	kg	Integrated circuit, logic type (GLI) market for integrated circuit, logic type Cut-off, S	Sensors
Machine bed	280.42	kg	Cast iron (GLI) market for cast iron Cut-off, S	Cast iron

Dedicated Incremental Forming Machine

Material	Value	Units	Input on SimaPro	Comments
Metal Sheet	0.44276	kg	Steel, low-alloyed (GLI) market for steel, low-alloyed Cut-off, S	151x 215 mm sheet
Forming Tool	1.8582	kg	Steel, low-alloyed (GLI) market for steel, low-alloyed Cut-off, S	10 mm diameter hemi-sphere tip
Support Tool	1.8582	kg	Steel, low-alloyed (GLI) market for steel, low-alloyed Cut-off, S	10 mm diameter hemi-sphere tip
Motor x2				
	1 m		Cable, three-conductor cable (GLI) market for cable, three-conductor cable Cut-off, S	
	20 kg		Permanent magnet, for electric motor (GLI) market for permanent magnet, for electric motor Cut-off, S	
Clamping System				
Metal bars	172.778	kg	Steel, low-alloyed (GLI) market for steel, low-alloyed Cut-off, S	Assumed steel
Boots	80.117	kg	Steel, low-alloyed (GLI) market for steel, low-alloyed Cut-off, S	Assumed steel
Operator Console				
15" color graphic display	1	kg	Display, cathode ray tube, 17 inches (GLI) market for display, cathode ray tube, 17 inches Cut-off, S	
Keyboard	1	kg	Keyboard (GLI) market for keyboard Cut-off, S	
Indicator lights	0.01	kg	Light emitting diode (GLI) market for light emitting diode Cut-off, S	
Selector switches	0.01	kg	Switch, toggle-type (GLI) market for switch production, toggle-type Cut-off, S	
Geometric CAD CNC control	1	kg	Computer, desktop, without screen (GLI) market for computer, desktop, without screen Cut-off, S	
Axis Assembly				
Column x2 (X-axis, Z-axis)	104.89	kg	Steel, low-alloyed (GLI) market for steel, low-alloyed Cut-off, S	Assumed steel
Spindle x2 (Y-axis, W-axis)	71.07	kg	Steel, low-alloyed (GLI) market for steel, low-alloyed Cut-off, S	Assumed steel
Beam (W-axis, Z-axis)	51.27	kg	Steel, low-alloyed (GLI) market for steel, low-alloyed Cut-off, S	Assumed steel

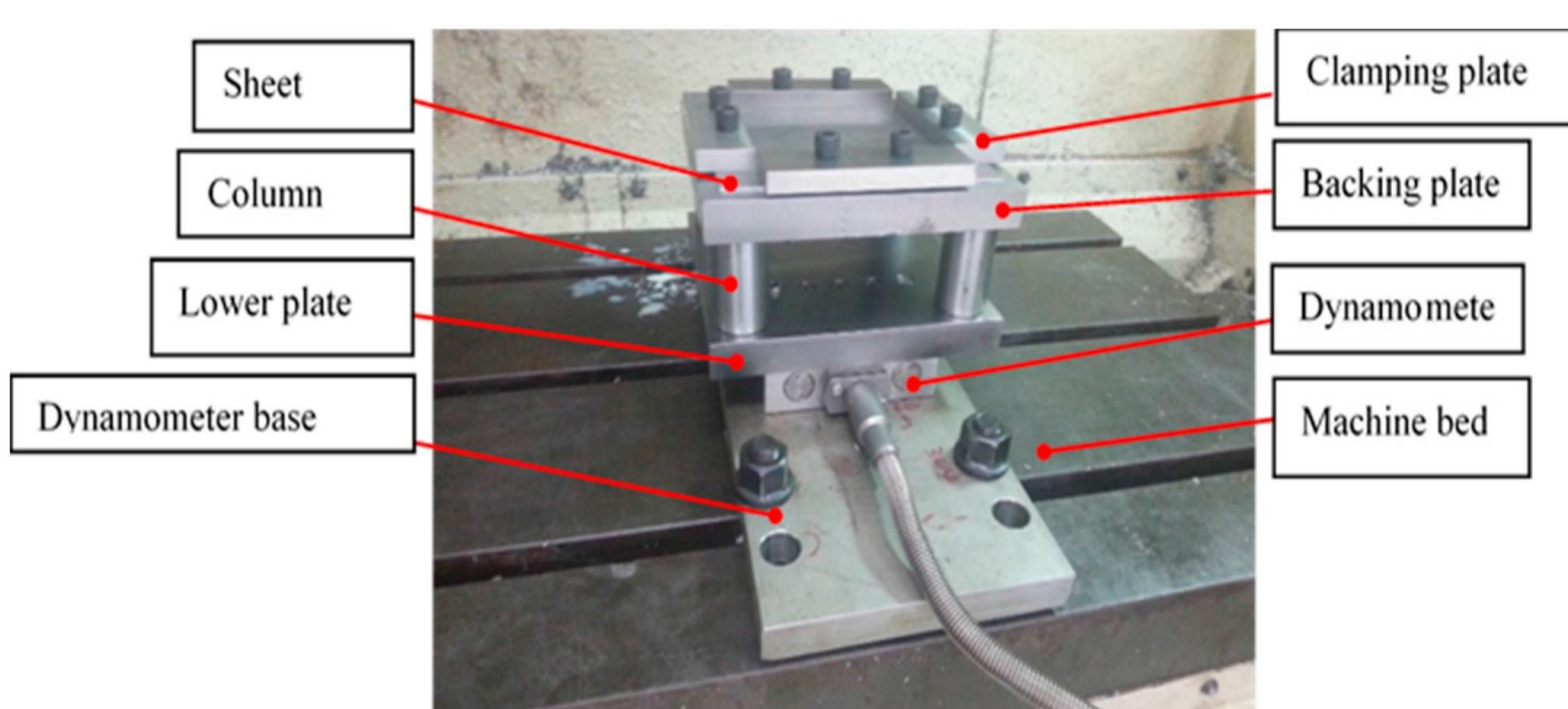
Graphs



Method: ReCiPe 2016 Midpoint (H) V1.08 / World (2010) H / Characterization
Comparing 1 p 'CNC IF Machine' with 1 p 'Dedicated IF Machine';

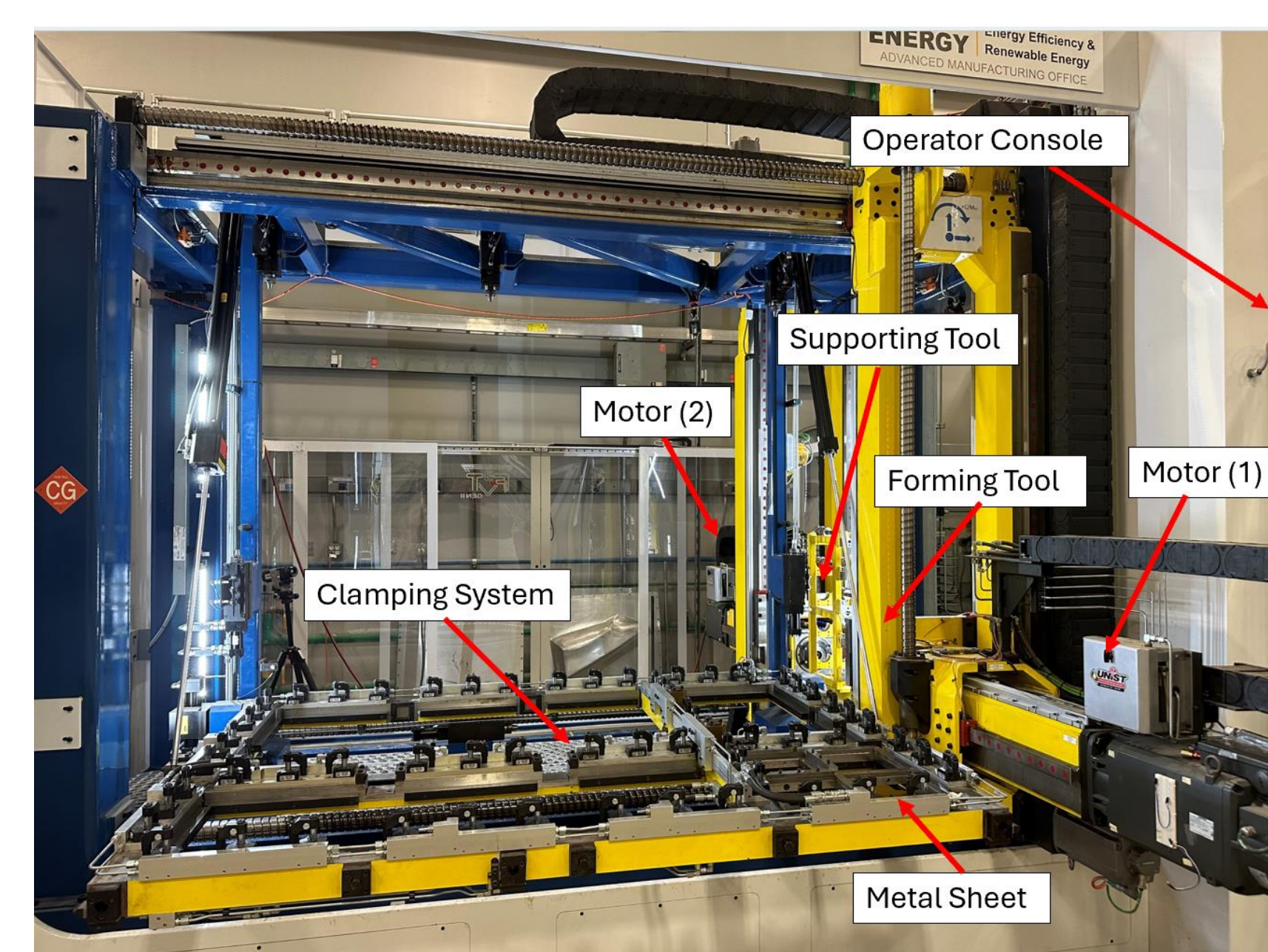
Incremental Forming Machines

CNC Incremental Forming Machine



Binamra Poudel Thesis

Dedicated Incremental Forming Machine



John Olson Manufacturing Center

Results/ Further Studies

- Dedicated Incremental Forming Machine has bigger environmental impact
 - Scale of Dedicated IF vs. CNC machine
- Complete rest of the life cycle phases for terrestrial and in-space manufacturing
- Perform LCA on robotic blacksmithing and compare results

Acknowledgements

We acknowledge the National Science Foundation's support via an FMRG award (#2328383). The views, findings, and conclusions expressed in this study are those of the authors and do not necessarily reflect the views of the funding agencies.

I would like to thank my advisors for the REU project, including: Dr. Weiwei Mo, Dr. Brad Kinsey, and Dr. Jinjin Ha.

References

- Binamra (2018) *Incremental Sheet Forming Method* [Bachelor's thesis, Hame University of Applied Sciences]
- Hirogaki, T. (2011) *Environmental Impact of Desktop-Sized Five-Axis CNC Machine....* Journal of Environment and Engineering, 6(2) 242-252.
- Ingarao (2020) *The case of Single Point Incremental Forming...* 32(2021) 145-153

This poster template provided courtesy of UNH ESRC Poster Printing Services

Trust us to make your poster look **GREAT!**

Website: <http://posters.unh.edu>
Poster Guide: <http://goo.gl/1E7TJY>



DELETE THIS SLIDE BEFORE PRINTING