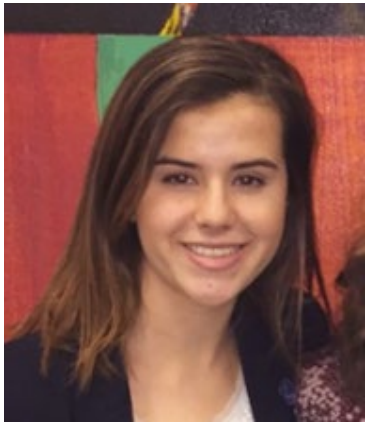
THE OHIO STATE UNIVERSITY

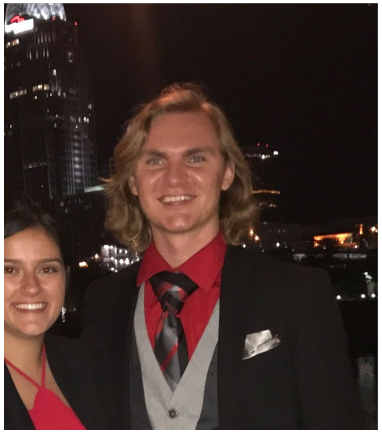
Ma2 Active Window Group Preliminary Design Review

Brigid Hayes, Michael Nye, Eddie Ondrejech, Brandon Price

Team Introduction



Brigid Hayes
Mechanical Engineering



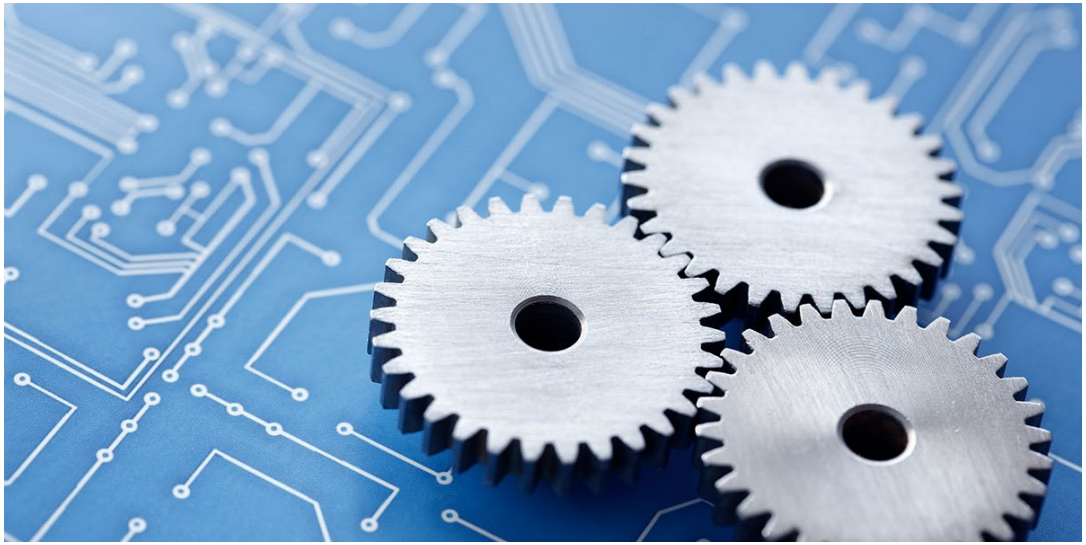
Michael Nye
Electrical Engineering

Eddie Ondrejech
Mechanical Engineering

Brandon Price
Electrical Engineering

Agenda

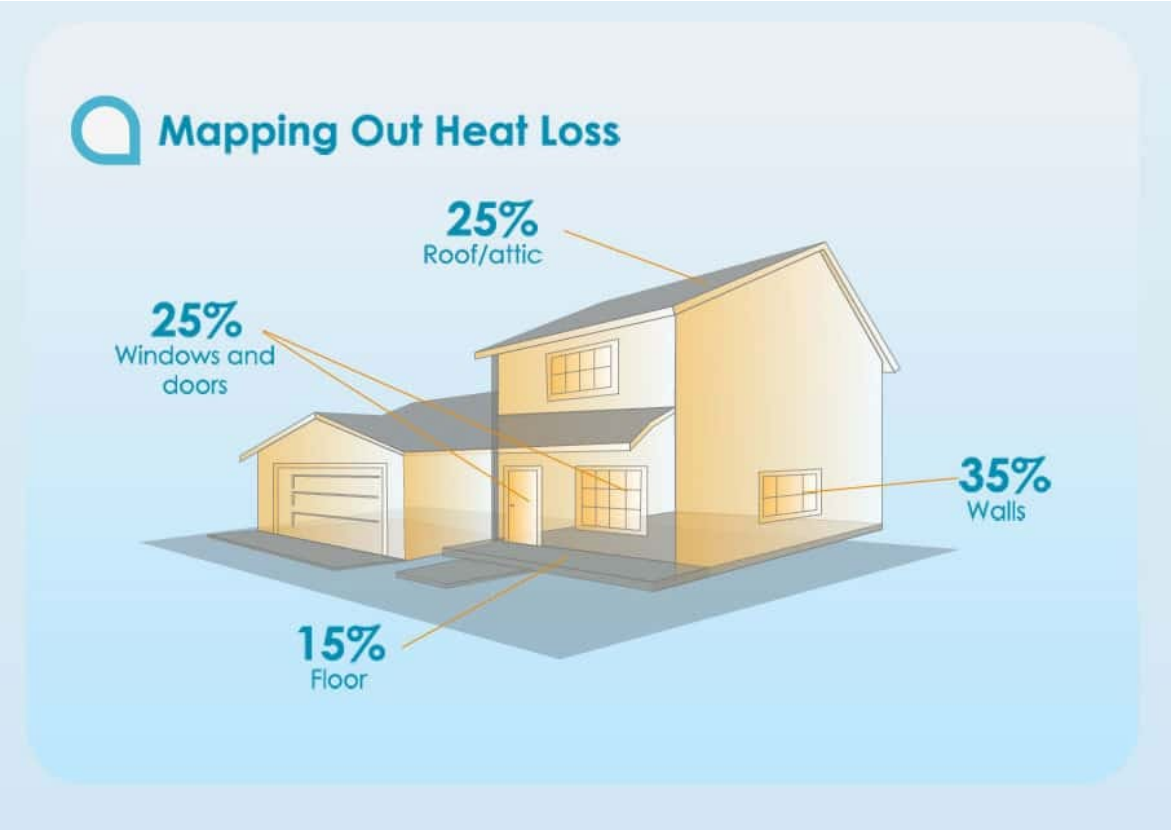
- Problem Definition
- Functional Requirements and How to Achieve Those
- Evaluating Selection Criteria
- Concepts and Ratings
- Next Steps and Questions



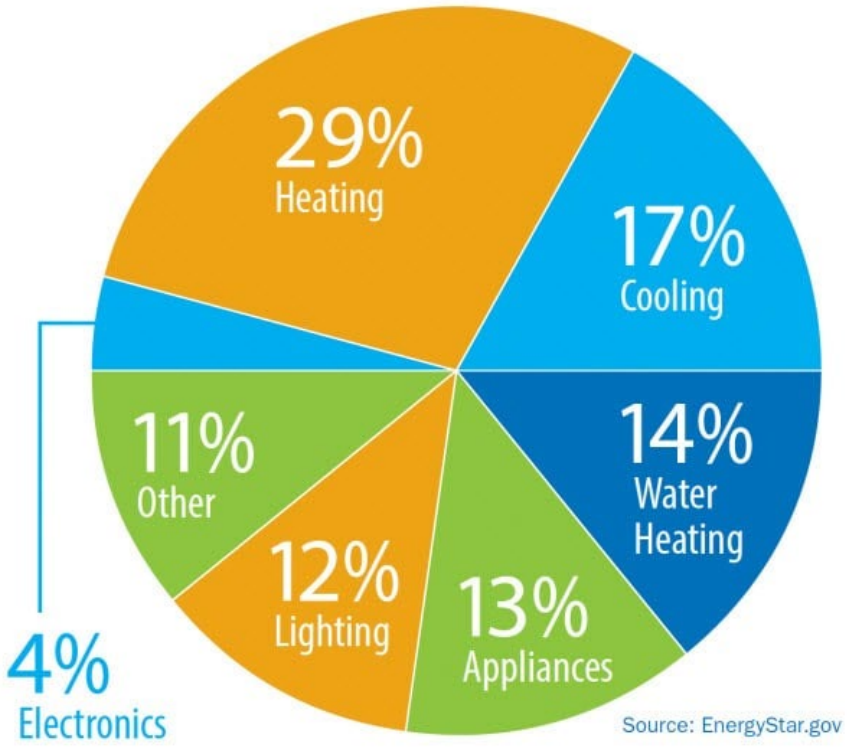
The Problem

On average, buildings in America lose 25% of energy through windows which is causing typical household owners and renters to pay more in heating and cooling every year.

The Problem


Mapping Out Heat Loss
25%
Roof/attic
25%
Windows and
doors
35%
Walls
15%
Floor

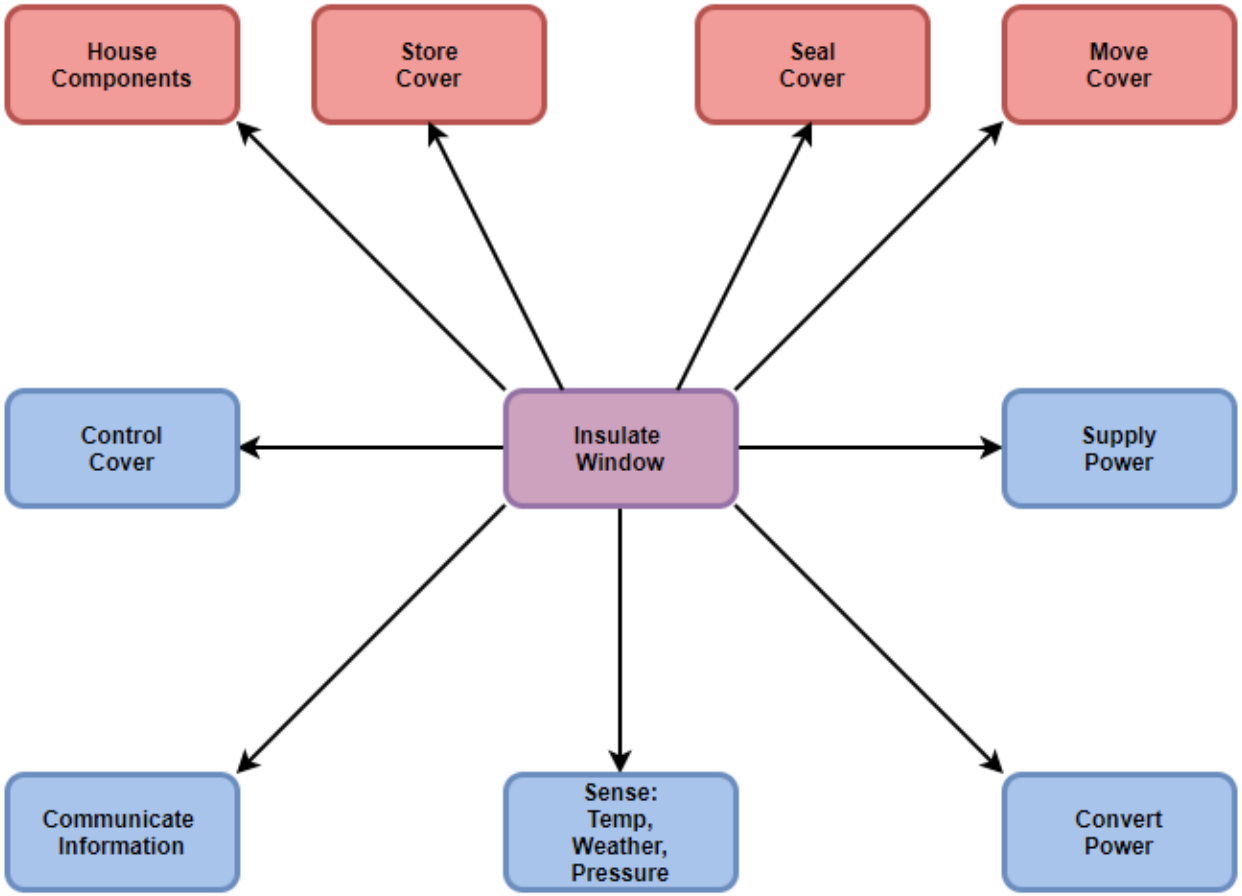
Energy Use Breakdown
(Based on average use per household)



Quantifying Insulation

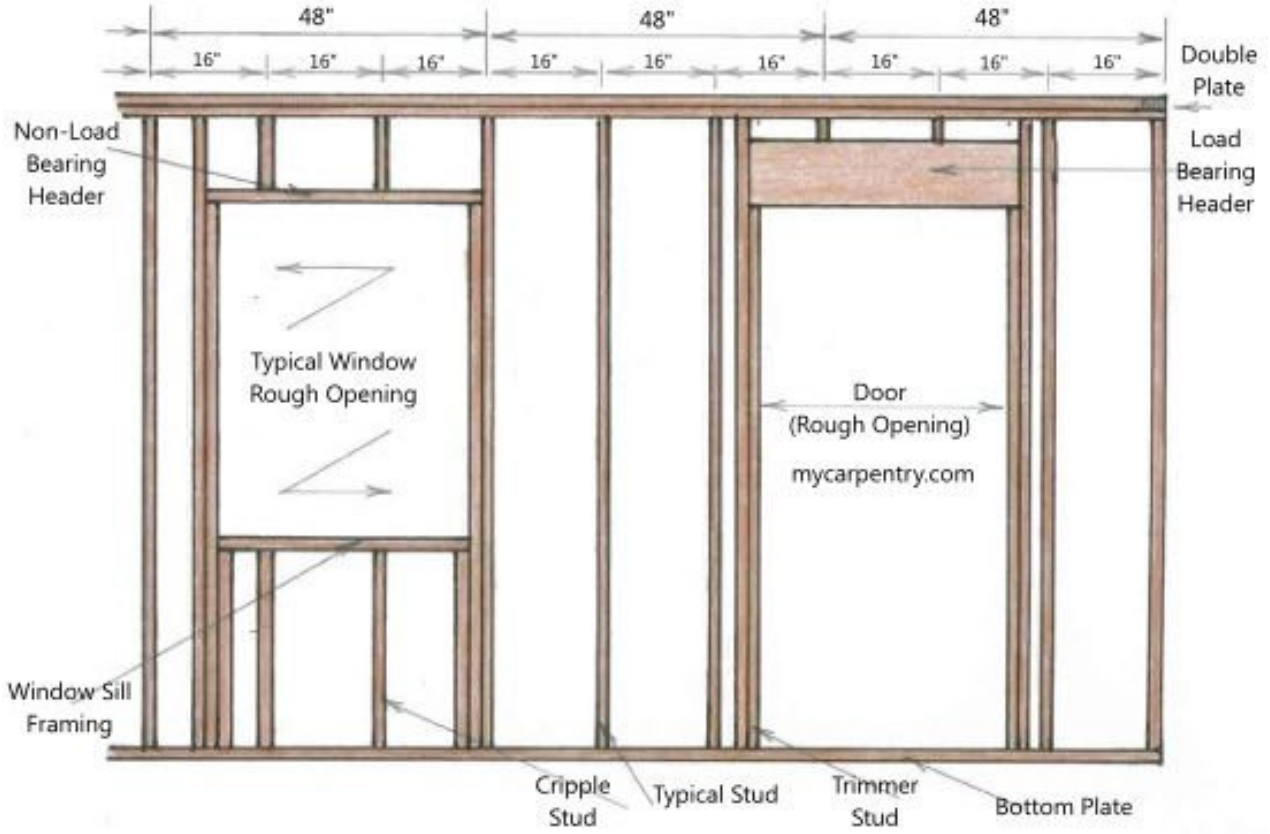
Zone	Attics	WALLS		Floors	Crawlspaces
		2x4	2x6		
1	R30 to R49	R13 to R15	R19 to R21	R13	R13
2	R30 to R60	R13 to R15	R19 to R21	R13	R13 to R19
3	R30 to R60	R13 to R15	R19 to R21	R25	R19 to R25
4	R38 to R60	R13 to R15	R19 to R21	R25 to R30	R25 to R30
5	R49 to R60	R13 to R15	R19 to R21	R25 to R30	R25 to R30
6	R49 to R60	R13 to R15	R19 to R21	R25 to R30	R25 to R30
7	R49 to R60	R13 to R15	R19 to R21	R25 to R30	R25 to R30

Functional Requirements

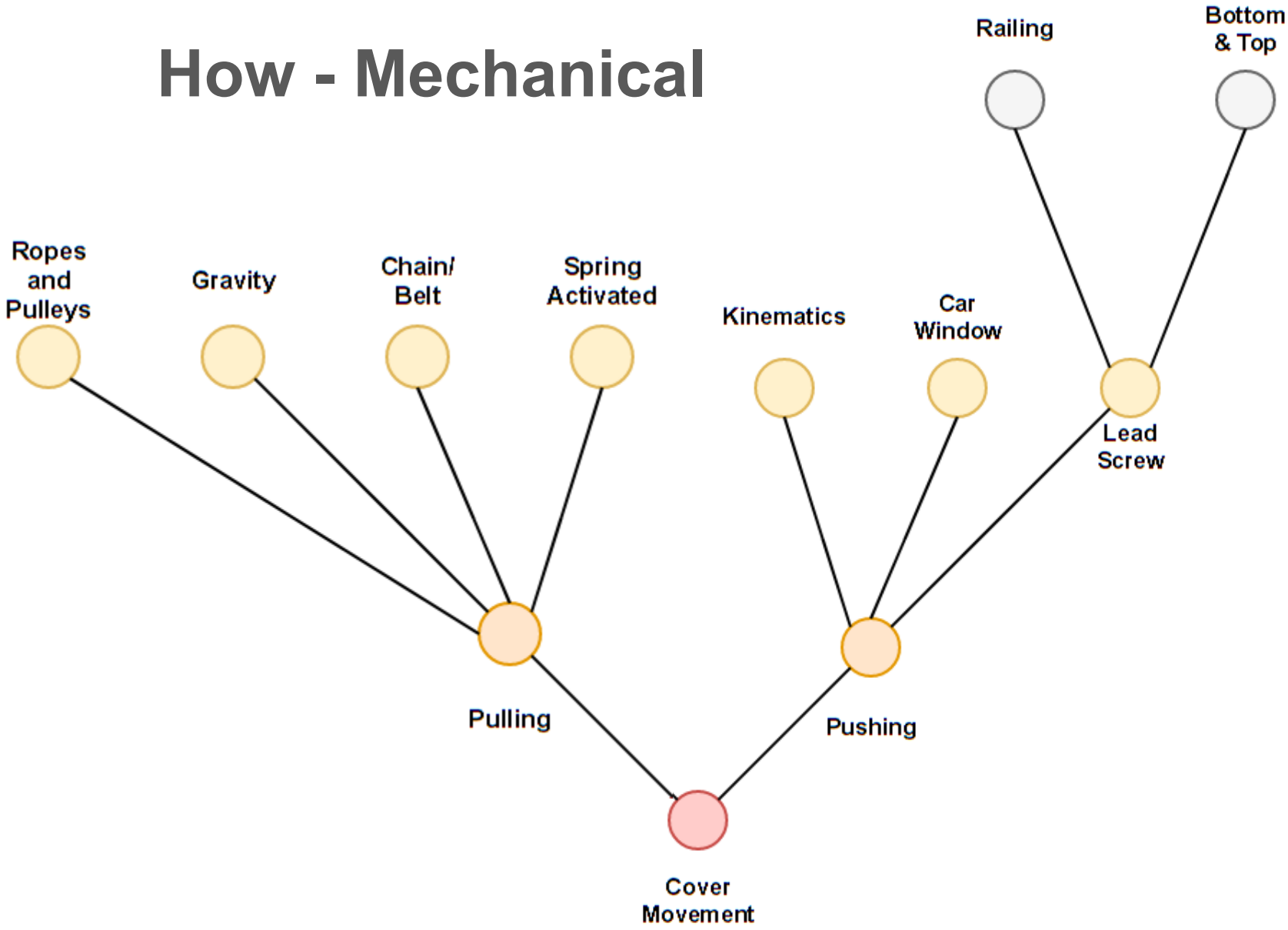


Installation

Levels of Modification



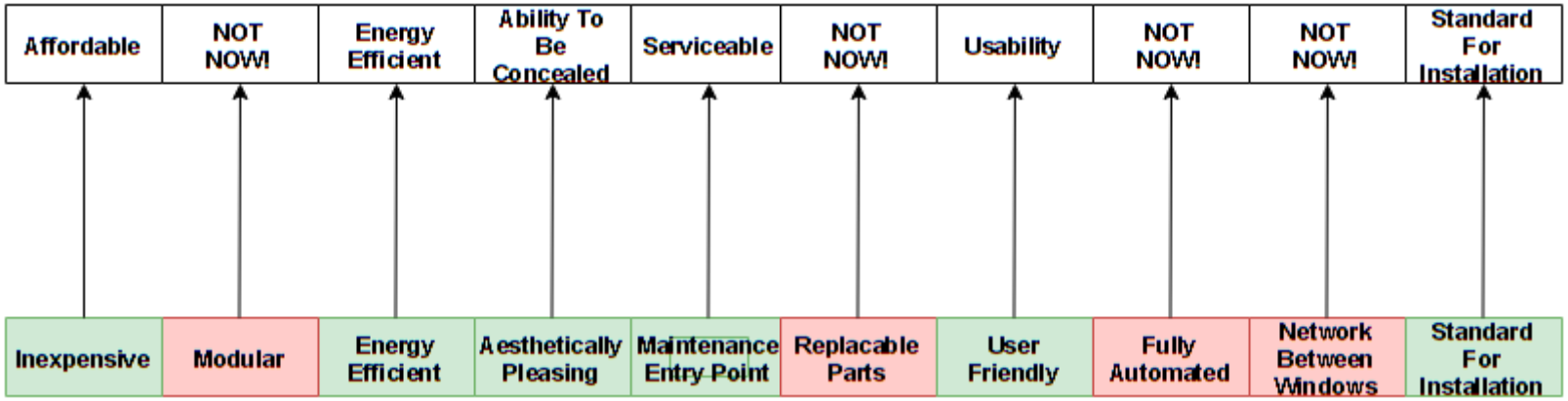
How - Mechanical



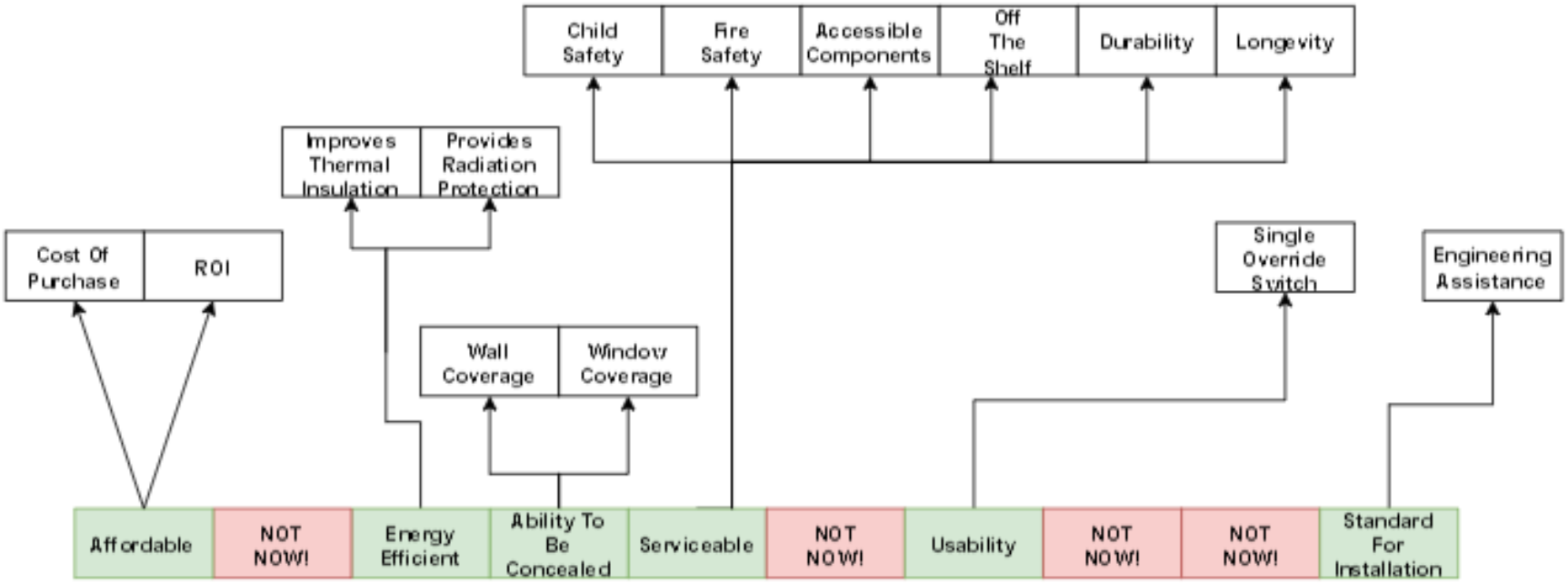
Concept Generation - Expand Selection Criteria

Inexpensive	Modular	Energy Efficient	Aesthetically Pleasing	Maintenance Entry Point	Replacable Parts	User Friendly	Fully Automated	Network Between Windows	Standard For Installation

Concept Generation - Expand Selection Criteria



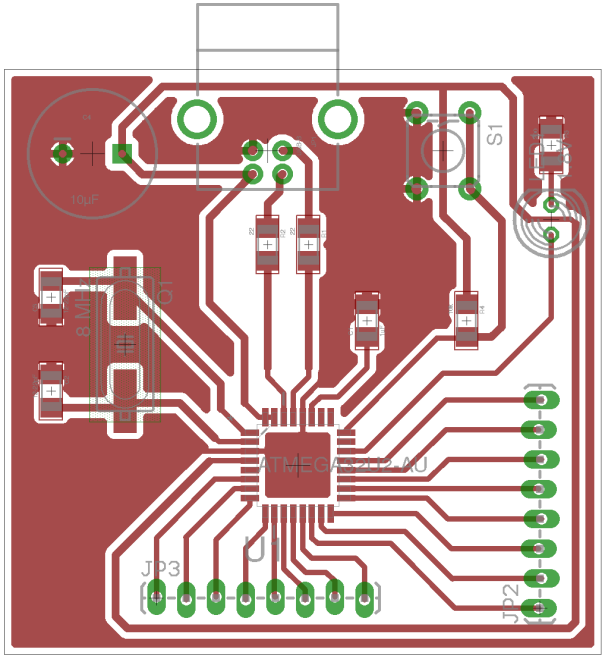
Concept Generation - Expand Selection Criteria



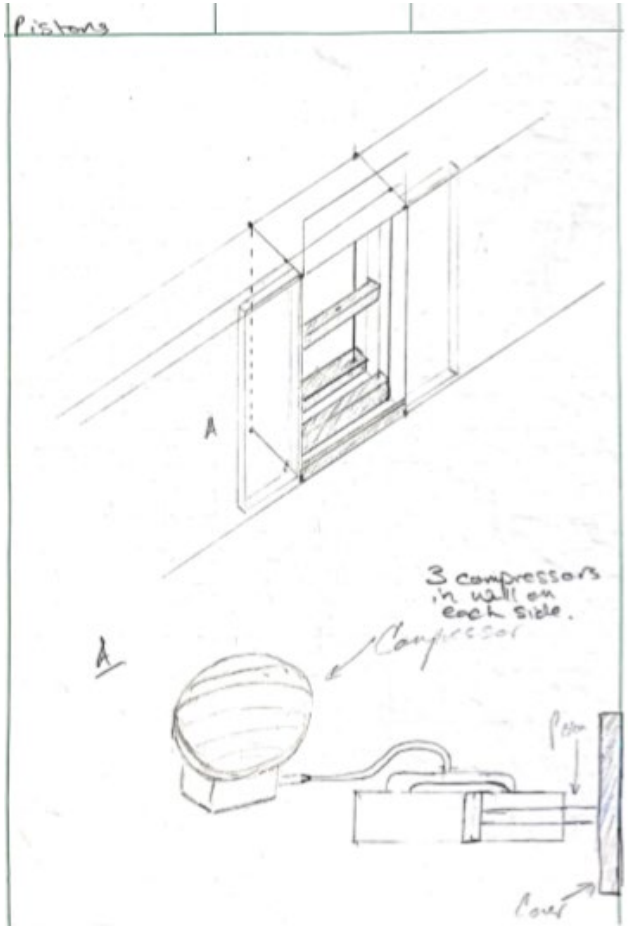
Concept Development

- Mechanical and Electrical designs were considered separately for this stage
- Any matchup would work ⟹ screening process

simplified

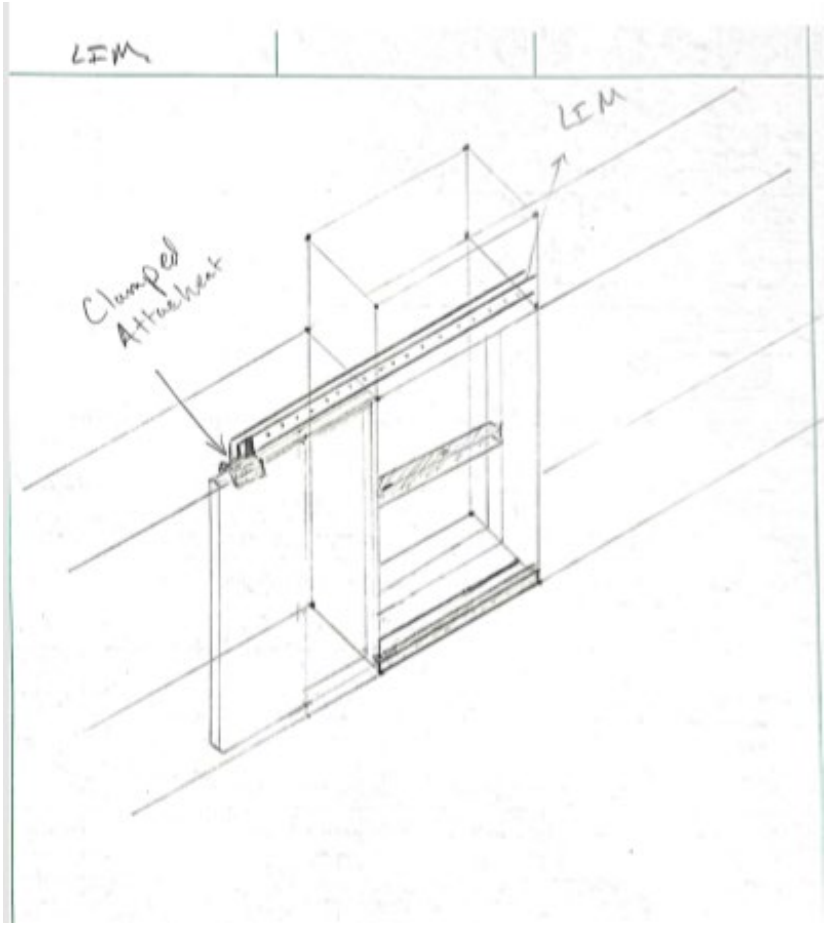


Mechanical Concepts



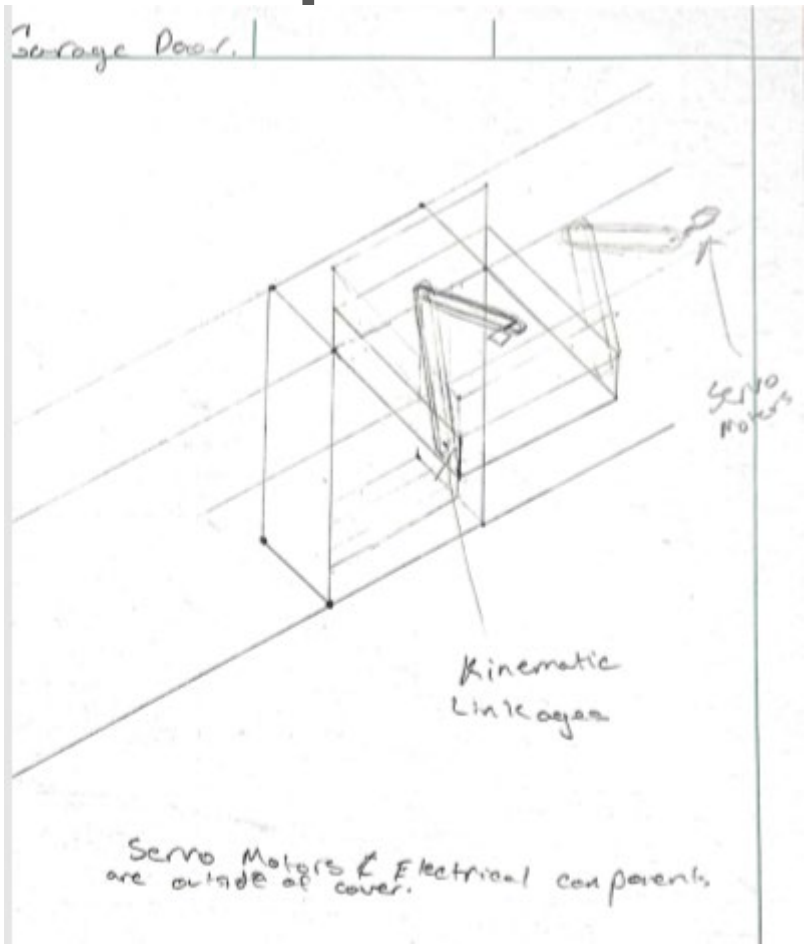
Concept M1 - Air Compressor

Mechanical Concepts



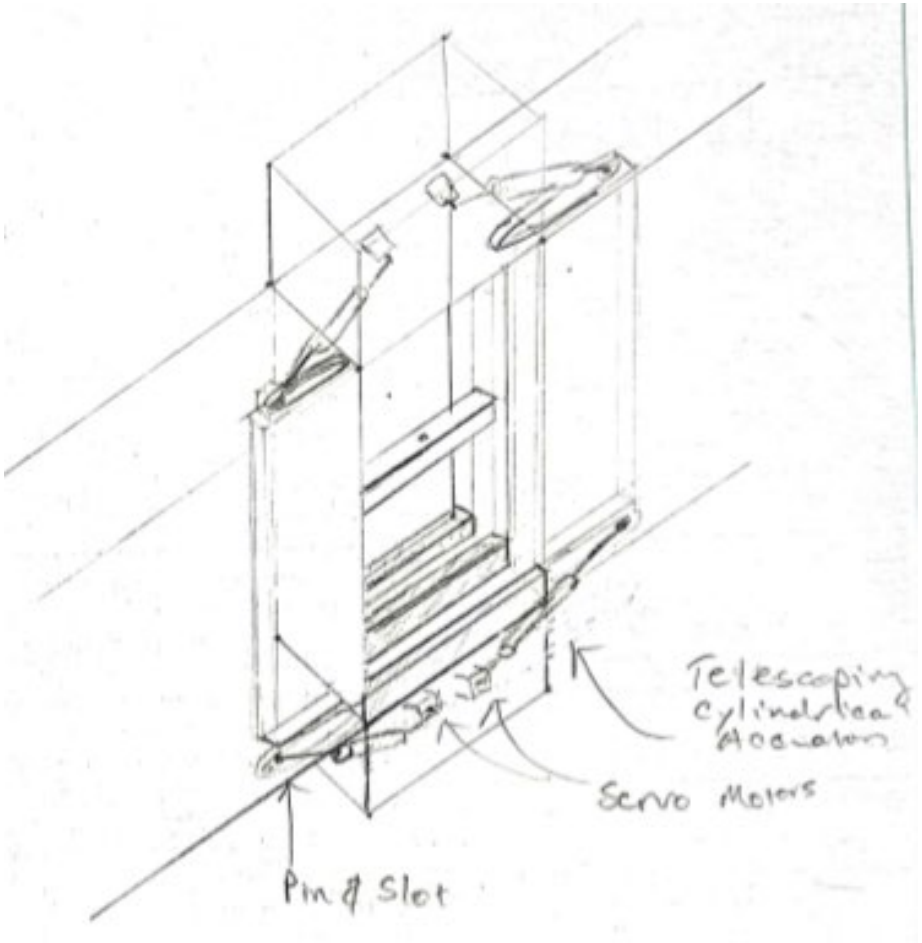
Concept M2 - Linear Induction Motor

Mechanical Concepts



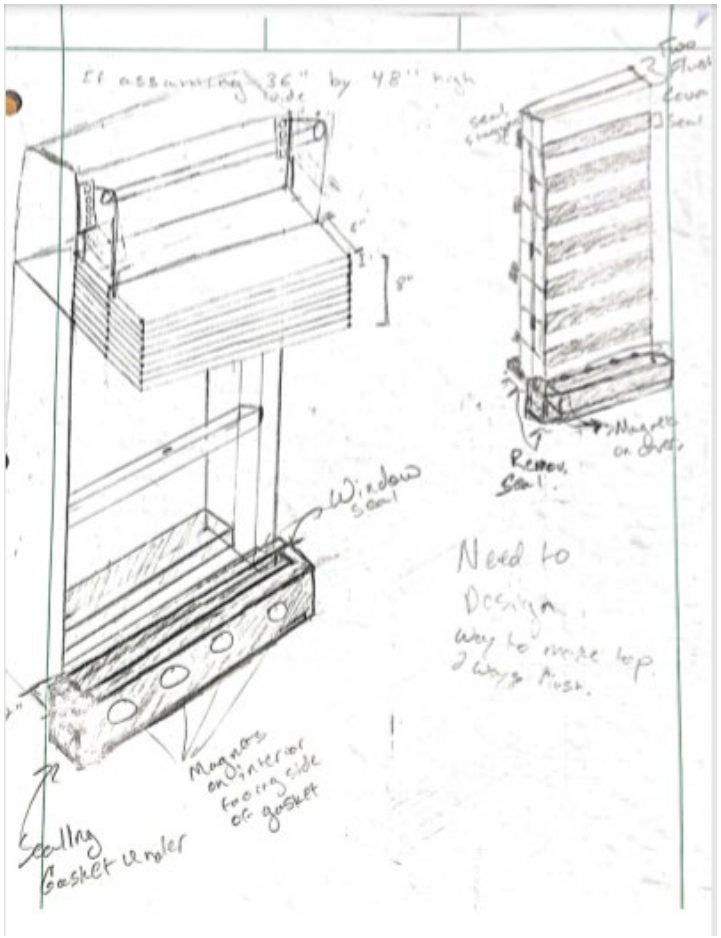
Concept M3 - Garage Door

Mechanical Concepts



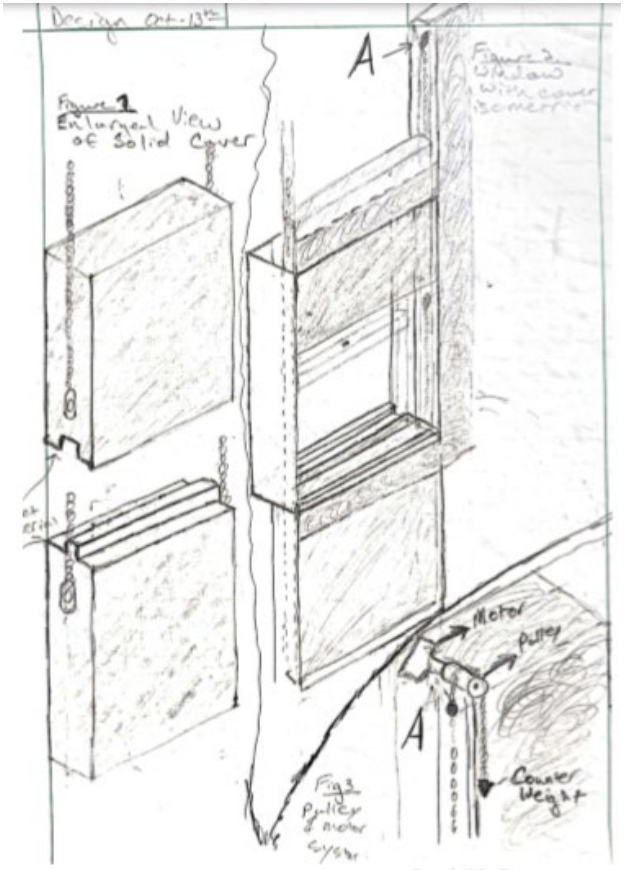
Concept M4 - Servomotors

Mechanical Concepts



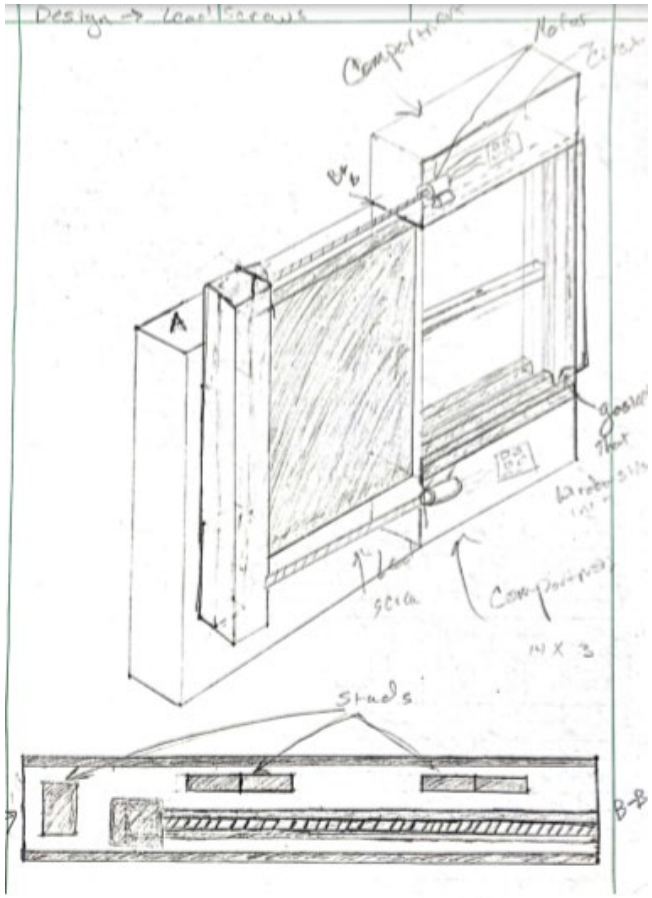
Concept M5 - Venetian Blinds

Mechanical Concepts



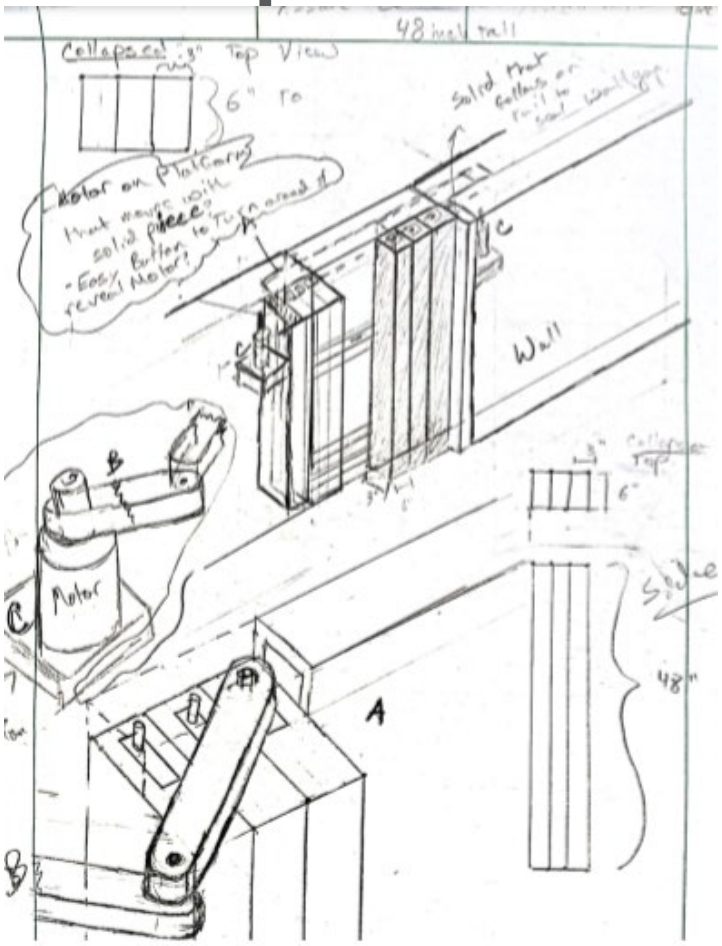
Concept M6 - Counter Weights

Mechanical Concepts



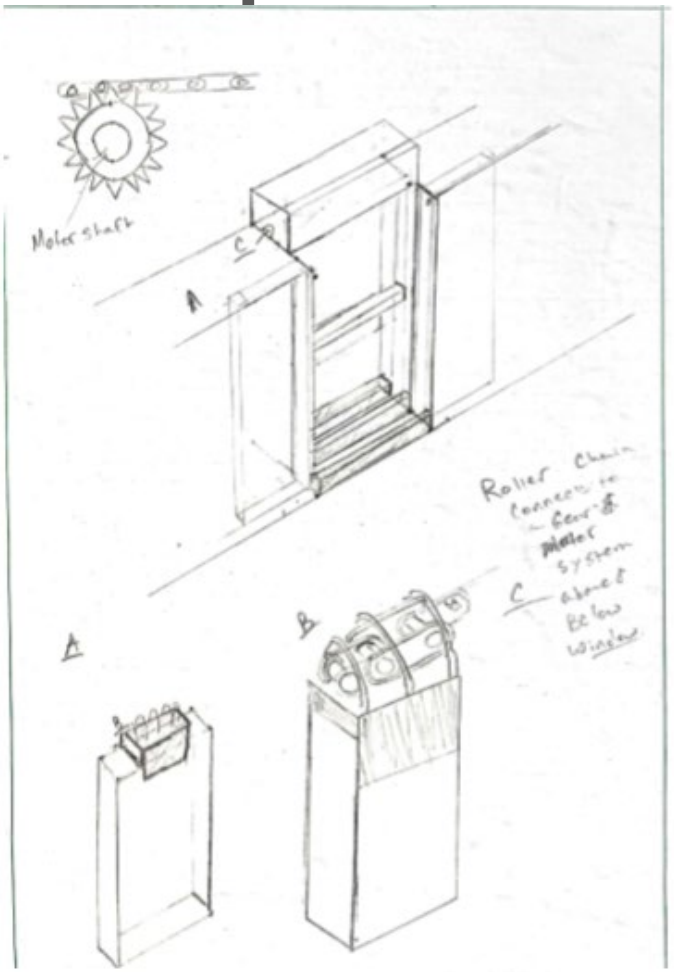
Concept M7 - Lead Screw

Mechanical Concepts



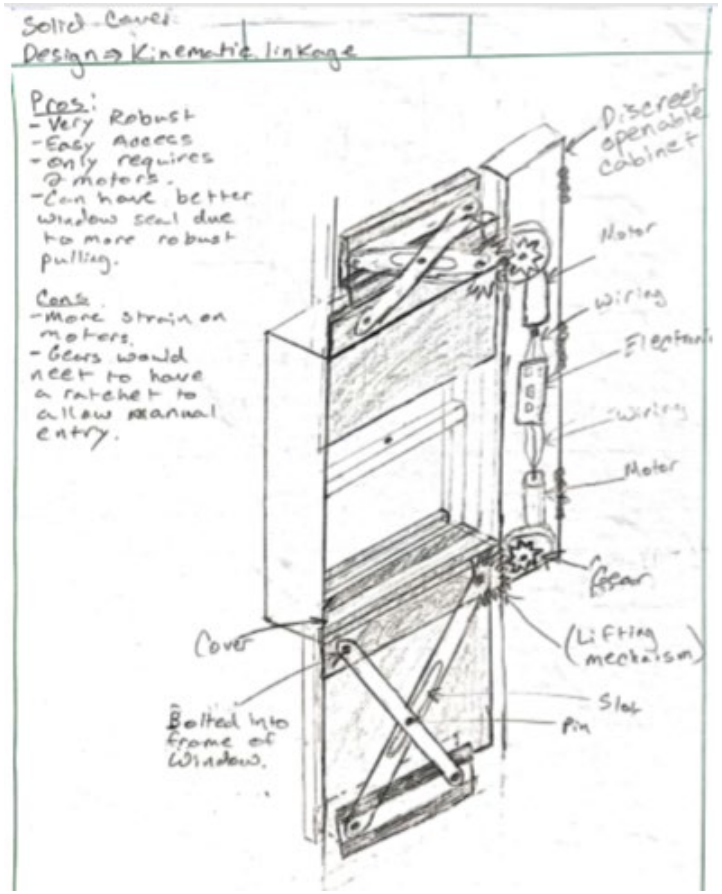
Concept M8 - Trifold

Mechanical Concepts



Concept M9 - Belt Drive

Mechanical Concepts



Concept M10 - Car Window

Mechanical Concept Screening

Selection Criteria	Metrics	Goal	Base Model	Car Window	Trifold	Lead Screw	Venetian	Counter Weights	Belt drive	Linear Induction Motor	Garage Door Style Linkages	Servos+ Actuators	Piston	Chain+ Magnet
Affordable														
Cost of Purchase	$	450	0	--	--	-	-	--	--	----	-	---	--	---
ROI	Years To Repay	7	0	0	0	0	0	0	0	0	0	0	0	0
Energy Efficient														
Improves Thermal Insulation of Window	R value	R14	0	++++	++++	++++	++++	++++	++++	++++	++++	++++	++++	++++
Provides Radiation Protection	Exterior reflectivity	60% Reflective	0	++++	++++	++++	++++	++++	++++	++++	++++	++++	++++	++++
Ability to Be Concealed														
Square inches of wall covered when not deployed (%) (Assuming 28 x 44 window)	See Definitions	1	0	0	0	0	--	0	0	0	-	0	0	0
Square inches of Window covered when not deployed (%)	See Definitions	1	0	0	0	0	0	0	0	0	0	0	0	0
Serviceable														
Child Safety	Y/N	Y	0	-	0	0	0	0	-	0	--	0	0	+
Fire Safety (Can it be opened easily manually)														
Components are accessible	See Definitions	2 or 1	0	-	0	--	++	-	0	0	0	--	--	-
Solution is composed of common "off the shelf" parts	Y/N	Y	0	0	0	++	--	+	+	--	-	0	0	-
Durability (Easily broken due to force)	See Definitions	2 or 1	0	++	+	++	--	0	--	0	0	0	0	0
Longevity (Normal wear)	See Definitions	2 or 1	0	0	0	++	-	-	--	0	0	0	0	0
Usability														
Single Override switch (Multiple Settings)	Y/N	Y	0	++	++	++	++	++	++	++	++	++	++	++
Standard for installation														
Need for engineering assistance	Y/N	N	0	-	0	0	0	0	-	---	--	0	-	-
Net Score			0	7	9	13	5	7	3	1	3	5	5	7
Rank			11	3	2	1	5	3	8	10	8	5	5	3

Mechanical Concept Scoring - First draft

Selection Criteria		Car Window		Lead Screw		Trifold		Counter Weight		Chain (with Magnet/Ratchet)	
Affordable	Weight	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score
Cost of Purchase	10.0%	3	0.30	4	0.40	3	0.30	4	0.40	5	0.50
ROI	10.0%	5	0.50	5	0.50	2	0.20	5	0.50	5	0.50
Energy Efficient											
Improves Thermal Insulation of Window	20.0%	5	1.00	5	1.00	4	0.80	5	1.00	5	1.00
Provides Radiation Protection	10.0%	5	0.50	5	0.50	5	0.50	5	0.50	5	0.50
Ability to Be Concealed											
Square inches of wall covered when not deployed (%) (Assuming 28 x 44 window)	1.0%	4	0.04	4	0.04	2	0.02	4	0.04	4	0.04
Square inches of Window covered when not deployed (%)	4.0%	5	0.20	5	0.20	5	0.20	5	0.20	5	0.20
Serviceable											
Child Safety	7.5%	2	0.15	3	0.23	4	0.30	5	0.38	4	0.30
Fire Safety (Can it be opened easily manually)	7.0%	3	0.21	2	0.14	4	0.28	5	0.35	5	0.35
Components are accessible	4.0%	5	0.20	5	0.20	3	0.12	2	0.08	4	0.16
Solution is composed of common "off the shelf" parts	4.0%	4	0.16	5	0.20	3	0.12	4	0.16	5	0.20
Durability (Easily broken due to force)	6.0%	4	0.24	5	0.30	3	0.18	3	0.18	4	0.24
Longevity (Normal wear)	4.0%	4	0.16	5	0.20	3	0.12	2	0.08	3	0.12
Usability											
Single Override switch (Multiple Settings)	2.5%	5	0.13	5	0.13	5	0.13	5	0.13	5	0.13
Standard for installation											
Need for engineering assistance	10.0%	3	0.30	4	0.40	3	0.30	5	0.50	4	0.40
Total Score			4.085		4.430		3.565		4.490		4.635
Rank			4		3		5		2		1

Mechanical Concept Scoring - Second Draft

Selection Criteria		Car Window		Lead Screw		Trifold		Counter Weight		Chain (with Magnet/Ratchet)	
Affordable	Weight	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score
Cost of Purchase	18.0%	3	0.54	4	0.72	3	0.54	4	0.72	5	0.90
ROI	15.0%	5	0.75	5	0.75	2	0.30	5	0.75	5	0.75
Energy Efficient											
Improves Thermal Insulation of Window	0.0%	5	0.00	5	0.00	4	0.00	5	0.00	5	0.00
Provides Radiation Protection	0.0%	5	0.00	5	0.00	5	0.00	5	0.00	5	0.00
Ability to Be Concealed											
Square inches of wall covered when not deployed (%) (Assuming 28 x 44 window)	0.0%	4	0.00	4	0.00	2	0.00	4	0.00	4	0.00
Square inches of Window covered when not deployed (%)	0.0%	5	0.00	5	0.00	5	0.00	5	0.00	5	0.00
Serviceable											
Child Safety	5.0%	2	0.10	3	0.15	4	0.20	5	0.25	4	0.20
Fire Safety (Can it be opened easily manually)	0.0%	3	0.00	2	0.00	4	0.00	5	0.00	5	0.00
Components are accessible	10.0%	5	0.50	5	0.50	3	0.30	2	0.20	4	0.40
Solution is composed of common "off the shelf" parts	2.0%	4	0.08	5	0.10	3	0.06	4	0.08	5	0.10
Durability (Easily broken due to force)	15.0%	4	0.60	5	0.75	3	0.45	3	0.45	4	0.60
Longevity (Normal wear)	15.0%	4	0.60	5	0.75	3	0.45	2	0.30	3	0.45
Usability											
Single Override switch (Multiple Settings)	0.0%	5	0.00	5	0.00	5	0.00	5	0.00	5	0.00
Standard for installation											
Need for engineering assistance	20.0%	3	0.60	4	0.80	3	0.60	5	1.00	4	0.80
Total Score			3.770		4.520		2.900		3.750		4.200
Rank			3		1		5		4		2

Mechanical Concept Scoring - Third Draft

Selection Criteria		Car Window		Lead Screw		Trifold		Counter Weight		Chain (with Magnet/Ratchet)	
Affordable	Weight	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score
Cost of Purchase	12.8%	3	0.38	4	0.51	3	0.38	4	0.51	5	0.64
ROI	12.8%	5	0.64	5	0.64	2	0.26	5	0.64	5	0.64
Energy Efficient											
Improves Thermal Insulation of Window	12.8%	5	0.64	5	0.64	4	0.51	5	0.64	5	0.64
Provides Radiation Protection	12.8%	5	0.64	5	0.64	5	0.64	5	0.64	5	0.64
Ability to Be Concealed											
Square inches of wall covered when not deployed (%) (Assuming 28 x 44 window)	0.0%	4	0.00	4	0.00	2	0.00	4	0.00	4	0.00
Square inches of Window covered when not deployed (%)	0.0%	5	0.00	5	0.00	5	0.00	5	0.00	5	0.00
Serviceable											
Child Safety	12.8%	2	0.26	3	0.38	4	0.51	5	0.64	4	0.51
Fire Safety (Can it be opened easily manually)	12.8%	3	0.38	2	0.26	4	0.51	5	0.64	5	0.64
Components are accessible	12.8%	5	0.64	5	0.64	3	0.38	2	0.26	4	0.51
Solution is composed of common "off the shelf" parts	0.0%	4	0.00	5	0.00	3	0.00	4	0.00	5	0.00
Durability (Easily broken due to force)	3.2%	4	0.13	5	0.16	3	0.10	3	0.10	4	0.13
Longevity (Normal wear)	3.2%	4	0.13	5	0.16	3	0.10	2	0.06	3	0.10
Usability											
Single Override switch (Multiple Settings)	3.9%	5	0.19	5	0.19	5	0.19	5	0.19	5	0.19
Standard for installation											
Need for engineering assistance	0.0%	3	0.00	4	0.00	3	0.00	5	0.00	4	0.00
Total Score			4.039		4.231		3.590		4.327		4.648
Rank			4		3		5		2		1

Mechanical Concept Summary

First	*Second*	*Third*	*Forward*
Chain Drive	Lead Screw	Chain Drive	Chain Drive
Counter Weight	Chain Drive	Counter Weight	Lead Screw
Lead Screw	Car Window	Lead Screw	Counter Weight

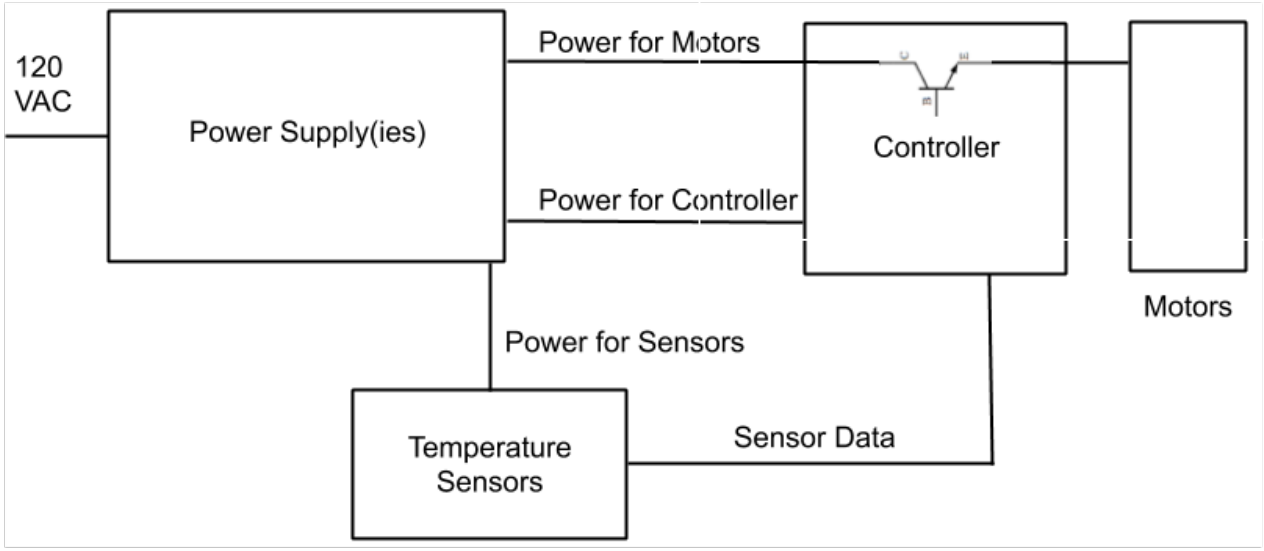
Electrical Concepts

Known/Dependent

- Controller - XMC4200
- Motors - Mechanical

Independent/Need Designed

- Power Supply(ies)
- Temperature Sensors



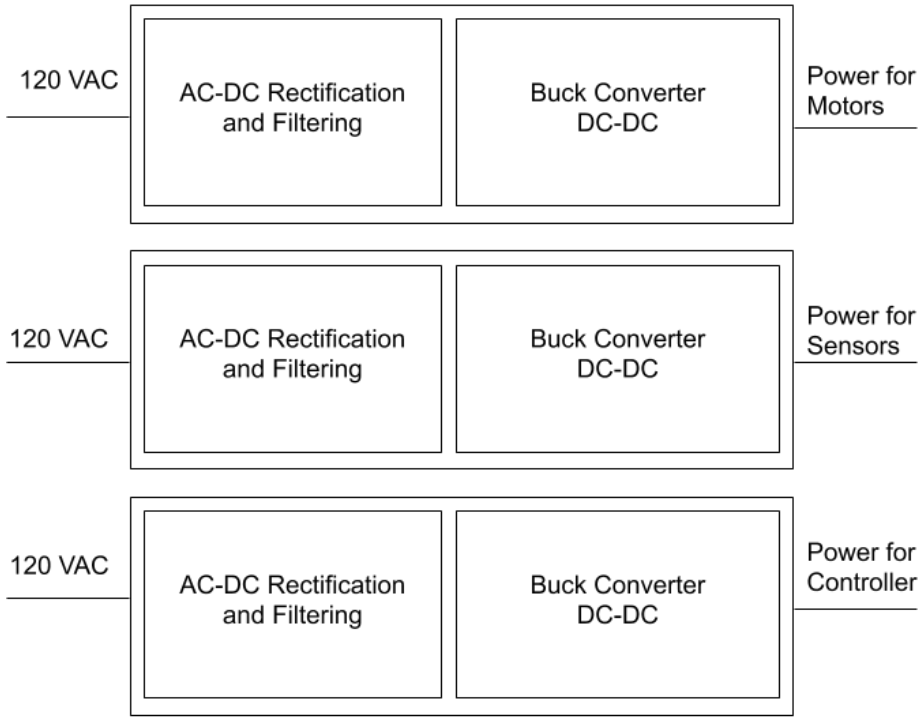
Needed Electrical Components

Power Supply Concepts

Convert 120 VAC to power for motors, controller, and sensors

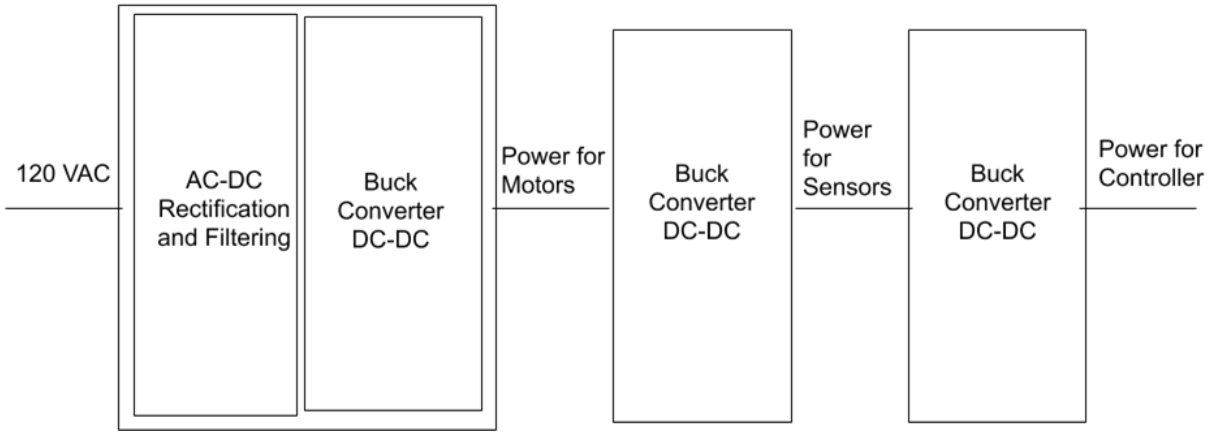
Screening Criteria

- Efficiency
- Cost
- Size of Components
- Isolated (for safety)
- Multiple Outputs

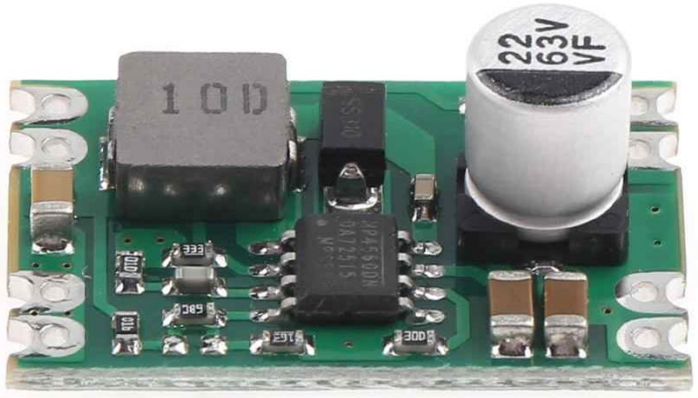


Power Supply Base Model

Power Supply Concepts

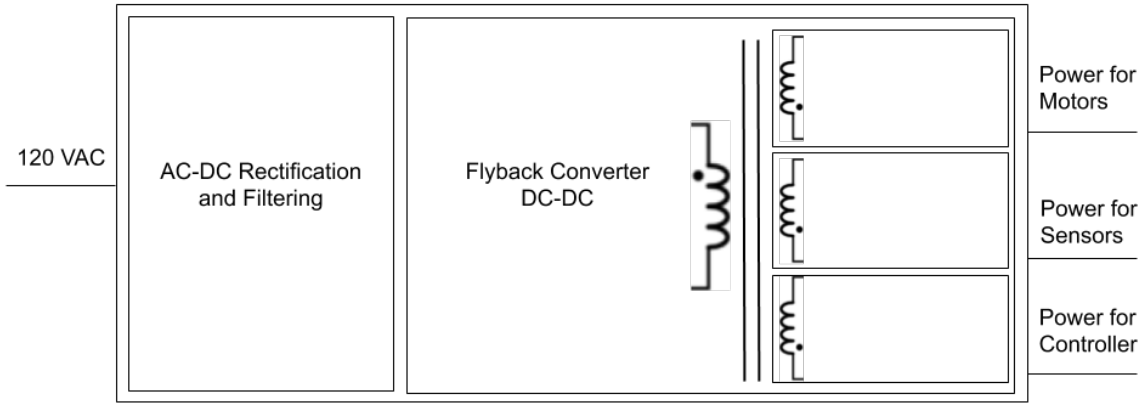


Concept E1: Three Buck Converters

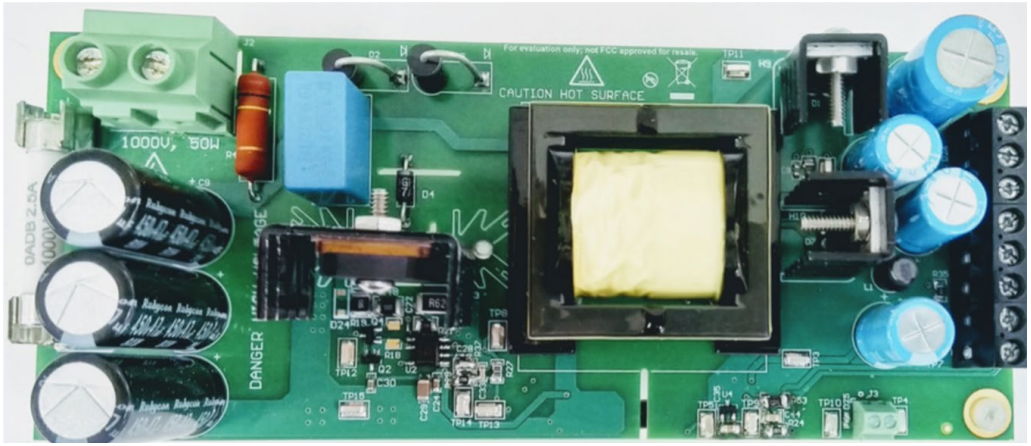


Example DC-DC Buck Converter

Power Supply Concepts

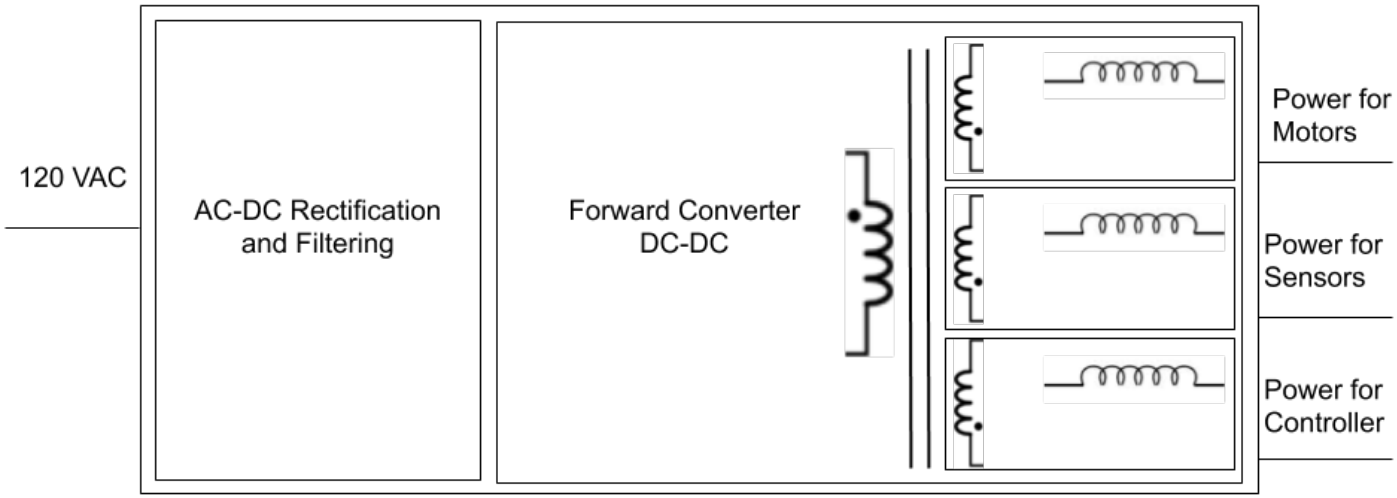


Concept E2: Flyback Converter



Example DC-DC Flyback Converter with Multiple Outputs

Power Supply Concepts



Concept E3: Forward Converter Design

Power Supply Concept Screening

Selection Criteria	Metrics	Goal	Base Model	Flyback Converter	Forward Converter	Buck Converters
Efficiency	%	>90%	0	-	--	0
Cost	$	Low	0	-	--	+
Size of Components	Size	Small	0	-	--	+
Isolated (input isolated from output for safety)	Yes/No	Yes	0	++	++	0
Multiple outputs (which would allow the need for only one Power Supply)	Yes/No	Yes	0	++	++	0
Net Score			0	1	-2	2
Rank			3	2	4	1

Power Supply Concept Scoring

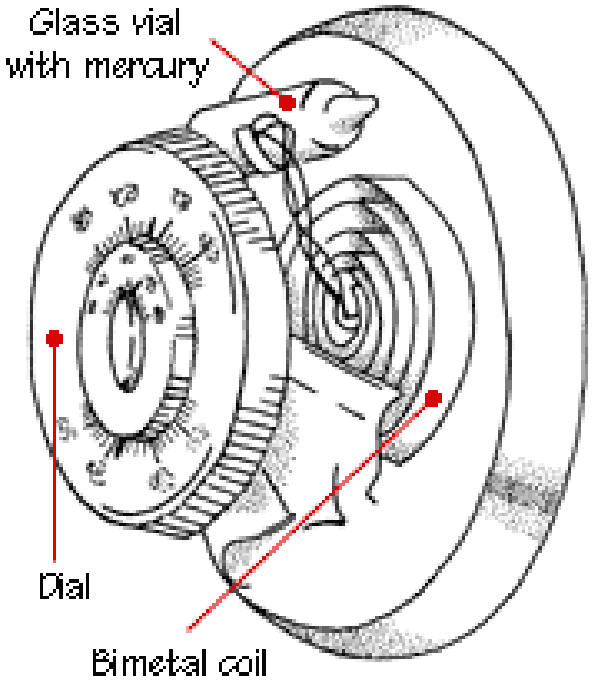
		Flyback Converter		Forward Converter		Buck Converters	
Selection Criteria	Weight	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score
Efficiency	40%	4	1.6	2	0.8	5	2
Cost	20%	3	0.6	2	0.4	5	1
Size of Components	5%	3	0.15	2	0.1	5	0.25
Isolated (input isolated from output for saftey)	10%	5	0.5	5	0.5	0	0
Multiple outputs (which would allow the need for only one Power Supply)	25%	5	1.25	5	1.25	0	0
Total Score			4.1		3.05		3.25
Rank			1		3		2

Temperature Sensor Concepts

Accurately measure temperature inside and outside the house

Screening Criteria

- Accuracy
- Cost



Temperature Sensor Base Model

Temperature Sensor Concepts

RTD Probe

Thermocouple Probe

NTC Thermistor Probe

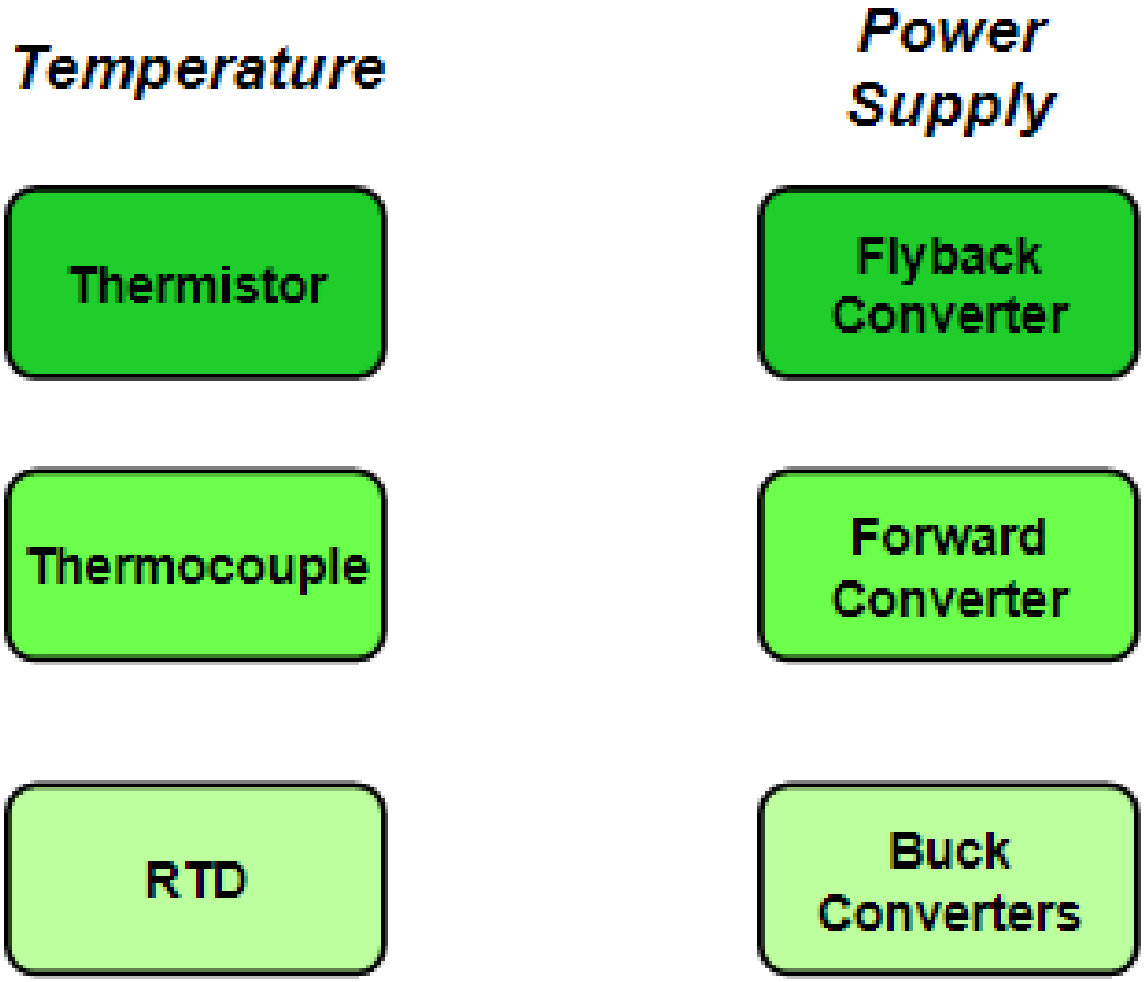
Temperature Sensor Concept Screening

Selection Criteria	Metrics	Goal	Base Model	NTC Thermistor	RTD	Thermocouple
Accuracy	degrees C	<= +-0.5	0	++	++	+
Cost	$	Low	0	+	-	++
Net Score			0	3	1	3
Rank			4	1	3	1

Temperature Sensor Concept Scoring

		NTC Thermistor		RTD		Thermocouple	
Selection Criteria	Weight	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score
Accuracy	65%	4	2.6	5	3.25	3	1.95
Cost	35.00%	4	1.4	1	0.35	5	1.75
Total Score			4		3.6		3.7
Rank			1		3		2

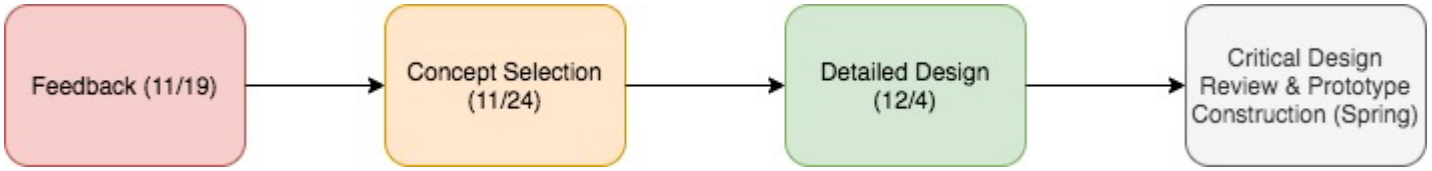
Electrical Concept Summary



Final Concepts- Summary

Electrical	*Mechanical*
Thermistor	Chain Drive
Flyback Converter	Lead Screw
	Counter Weight

Next Steps and Final Deliverables



- Functioning Prototype
- Poster for Virtual Design Showcase (4/22/21)
- Final Design Document (4/22/21)
- Final Project Presentation (4/22/21)

- → Does the team's progress align with Ma2 expectations?
- → Any input on the top 3 mechanical concepts?

Thank you!

Any Questions?