Decision Matrix

Below shows the decision matrix for each of the driver designs that advanced from the preliminary round of screening. This matrix includes a numbering system ranging from 0-5 , and that gives weight to each of the categories. (The "needs conversion" category did not receive any weight, and thus had no impact on the scoring. It was initially considered an important factor, but as further deliberation on the matter led to the conclusion that each of the designs would need a method of "energy conversion" in one sense or another, the category was no longer considered relevant is decision-making.)

Energy and manufacturability were taken to be the two biggest concerns with the project. It was equally important that the design meet the minimum flow rate while still being able to construct the design. If neither of these could be attained, then the idea was discarded as the project goals would not be met. Output and energy efficiency were taken to both fall into the "energy" category. Precision of manufacturing, manufacturability, and complexity were all considered to be components of the "manufacturability" category. This is why the weights of these subcategories roughly equals to each other (~32% each). The remaining percentage was divided up amongst the rest of the categories in what we perceived as their importance to the overall success of the project. The designs highlighted in red were rejected at this stage. However, it can be seen that the remaining designs all scored very similarly in their end results. Since no one design was a clear winner, we sought to differentiate even more, which can be seen in the next sheet/page.

The External Driver Design Matrix

Criteria	weight weights	Weight	Design											
			Foot pedal w/ flywheel		Bike pump		Tilt board		Hand crank		Fat lever arm		Bellows	
			Raw Score	*Weighted Score*	*Raw Score*	*Weighted Score*	*Raw Score*	*Weighted Score*	*Raw Score*	*Weighted Score*	*Raw Score*	*Weighted Score*	*Raw Score*	*Weighted Score*
output	2.250	21.0%	4	0.84	5	1.05	3	0.63	3	0.63	4	0.84	5	1.05
energy efficiency	1.250	11.7%	5	0.58	4	0.47	2	0.23	3	0.35	4	0.47	2	0.23
needs conversion	0	0.0%	2	0.00	5	0.00	4	0.00	3	0.00	4	0.00	5	0.00
precision of man.	2.000	18.7%	4	0.75	1	0.19	5	0.93	1	0.19	3	0.56	5	0.93
manufacturability	1.000	9.3%	3	0.28	1	0.09	4	0.37	3	0.28	4	0.37	4	0.37
complexity	0.500	4.7%	2	0.09	1	0.05	4	0.19	3	0.14	3	0.14	5	0.23
ease of use	1.500	14.0%	4	0.56	2	0.28	4	0.56	1	0.14	3	0.42	1	0.14
assembly	0.250	2.3%	2	0.05	5	0.12	4	0.09	4	0.09	4	0.09	5	0.12
durability	1.000	9.3%	3	0.28	2	0.19	3	0.28	4	0.37	4	0.37	2	0.19
size	0.300	2.8%	2	0.06	4	0.11	3	0.08	5	0.14	4	0.11	3	0.08
weight	0.500	4.7%	1	0.05	3	0.14	2	0.09	4	0.19	3	0.14	5	0.23
cost	0.150	1.4%	2	0.03	1	0.01	4	0.06	3	0.04	3	0.04	4	0.06
% (sum)		**100.0%**		**71.3%**		**53.9%**		**70.6%**		**51.3%**		**71.3%**		**72.9%**

Energy and manufacturability were again taken to be the two biggest concerns with the project. Output, output speed, and energy efficiency were included into the "energy" category. Precision of manufacturing, manufacturability, and complexity were all considered to be components of the "manufacturability" category. This time, however, the output was deemed to be slightly more important that the ability to manufacture the product well.

It was crucial that the design have the correct capacity, regardless of the driver, to pump the minimum amount of blood needed to satisfy the flow rate requirements. This area receives the most weight as a result. The remaining percentage was divided up amongst the rest of the categories in what we perceived as their importance to the overall success of the project. The designs highlighted in red were rejected at this stage. Though the cylindrical compressive diaphragm design scored the highest, several of the designs were once again very similar in the end results. To have consistency, we decided to also provide further analysis, as we did with the driver designs. Though low-scoring, the center-to-side fan pump advanced to the next round as it was the highest-scoring continuous system, and we did not yet know whether our driver would support pulsatile or continuous flow.

The Implantable Portion Design Matrix

Criteria	Weight	Design															
		Air driven dual piston		Circular Expansive Diaphragm		Circular Compressive Diaphragm		Cylindrical Expansive Diaph.		Cylindrical Compressive Diaph.		Center-to-Side Fan Pump		Center Fan Pump		Tube Roller Pump	
		Raw Score	*Weighted Score*	*Raw Score*	*Weighted Score*	*Raw Score*	*Weighted Score*	*Raw Score*	*Weighted Score*	*Raw Score*	*Weighted Score*	*Raw Score*	*Weighted Score*	*Raw Score*	*Weighted Score*	*Raw Score*	*Weighted Score*
output	20.20%	5	1.010	3	0.606	3	0.606	4	0.808	4	0.808	4	0.808	3	0.606	3	0.606
Output speed	16.16%	3	0.485	2	0.323	2	0.323	4	0.646	4	0.646	3	0.485	3	0.485	1	0.162
energy efficiency	16.16%	5	0.808	4	0.646	5	0.808	4	0.646	5	0.808	2	0.323	2	0.323	1	0.162
durability	8.08%	2	0.162	1	0.081	3	0.242	1	0.081	3	0.242	4	0.323	3	0.242	5	0.404
precision of man.	14.14%	2	0.283	4	0.566	4	0.566	4	0.566	4	0.566	4	0.566	3	0.424	5	0.707
complexity (risk factor)	12.12%	3	0.364	2	0.242	4	0.485	1	0.121	4	0.485	3	0.364	3	0.364	4	0.485
manufacturability	10.10%	4	0.404	4	0.404	5	0.505	4	0.404	4	0.404	3	0.303	3	0.303	5	0.505
ease of seal	2.02%	2	0.040	5	0.101	4	0.081	5	0.101	4	0.081	3	0.061	2	0.040	5	0.101
cost	1.01%	3	0.030	4	0.040	5	0.051	4	0.040	5	0.051	3	0.030	3	0.030	3	0.030
size	2.02%	4	0.081	4	0.081	5	0.101	4	0.081	5	0.101	5	0.101	5	0.101	3	0.061
% (sum)			**71.72%**		**60.20%**		**73.33%**		**68.28%**		**81.82%**		**65.25%**		**56.36%**		**63.23%**

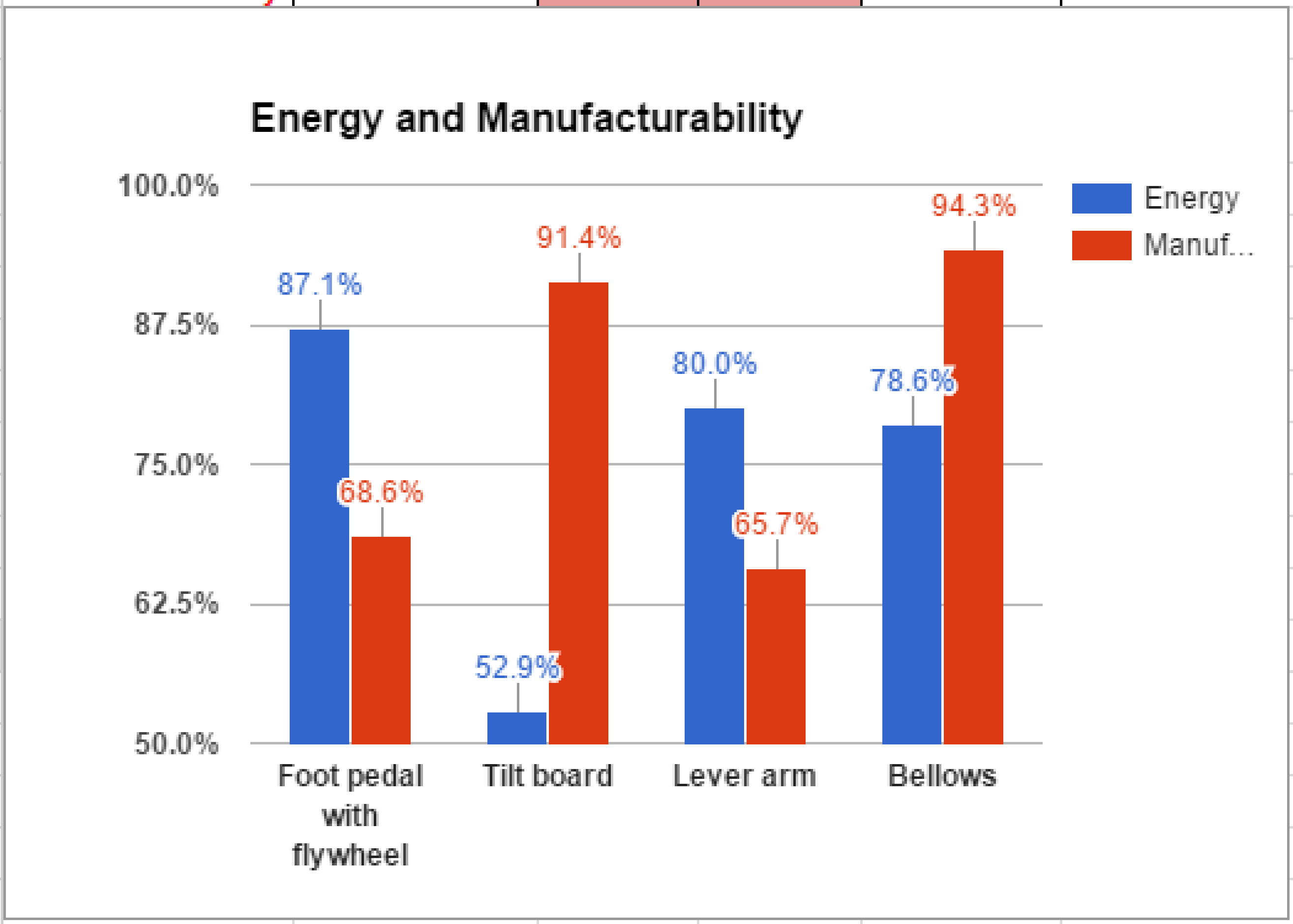
Extra Design Matrix Analysis

In order to better narrow down the decision for a driver design, we decided to consider only combined energy score versus the combined manufacturability score, as these were the two large overarching categories that we deemed most important. To compare these values, we summed the weighted scores for each subcategory (output and energy efficiency; and precision of manufacturing, manufacturability, and complexity) and then divided this number by the sum of the weighted percentage for the same subcategories. The results are shown below in both table and graphical form.

Although the tilt board received the highest manufacturability score, it also received the lowest energy score. We felt that though we could most likely construct the tilt board to generate enough energy in order to attain the minimum flow rate, we did not know if we could much exceed this. As there did not seem to be a lot of room for improvement upon the very bare minimum, we eliminated the tilt board design. The lever arm was also discarded as the total sum for both categories was less than the total sum for either the foot pedal or flywheel. As we did not yet know what implantable design the driver would be paired with, we left the final two designs for further analysis.

The External Driver Design Matrix

Extra Analysis: Driver Designs	Foot pedal with flywheel	Tilt board	Lever arm	Bellows
Energy	87.1%	52.9%	80.0%	78.6%
Manufacturability	68.6%	91.4%	65.7%	94.3%

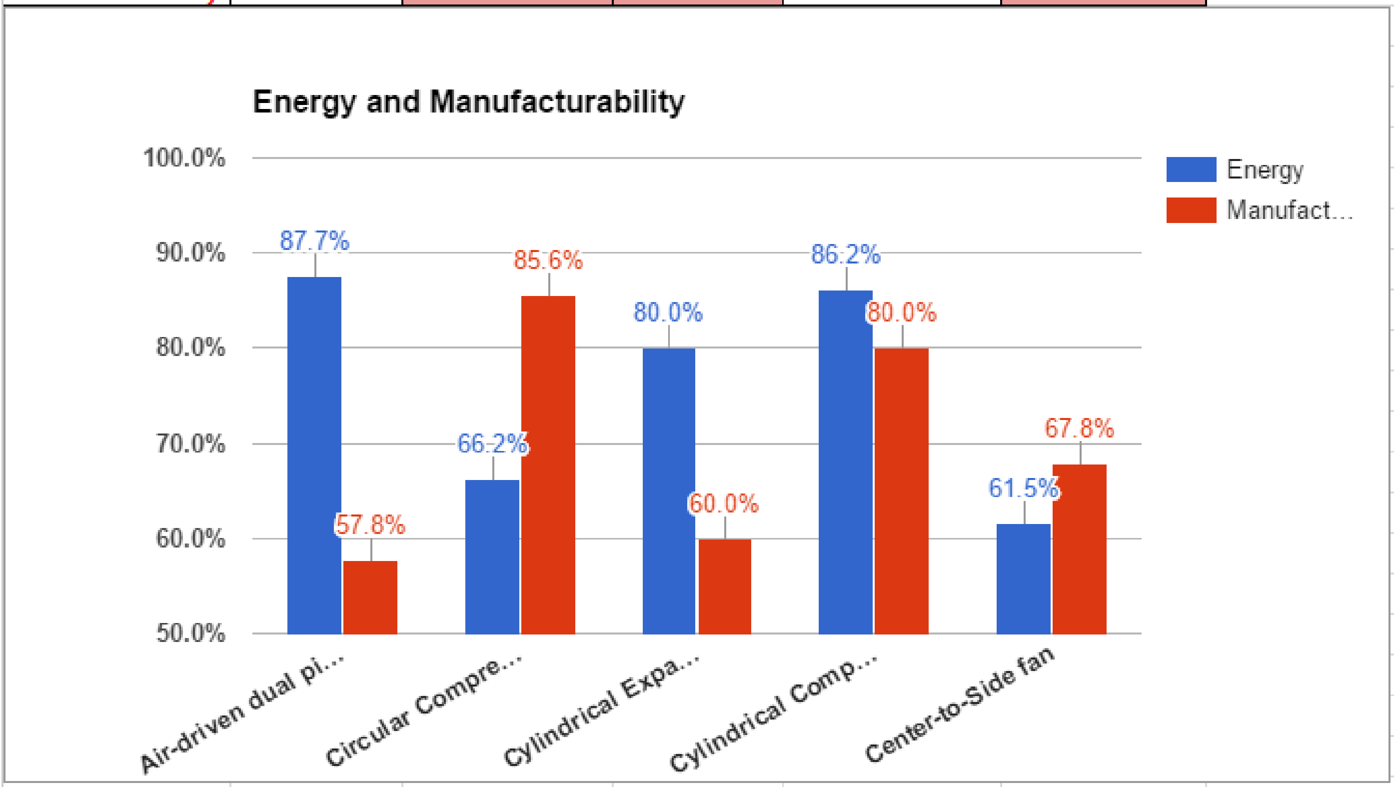


In order to better narrow down the decision for an implantable design, we decided to consider only combined energy score versus the combined manufacturability score, as these were the two large overarching categories that we deemed most important. To compare these values, we summed the weighted scores for each subcategory (output, output speed, and energy efficiency; and precision of manufacturing, manufacturability, and complexity) and then divided this number by the sum of the weighted percentage for the same subcategories. The results are shown below in both table and graphical form.

The center-to-side fan pump was shown to perform poorly in each of the two main categories. Therefore, it and continuous flow systems were discarded at this step. In addition, neither the circular compressive diaphragm and cylindrical expansive diaphragm performed as well as the cylindrical compressive diaphragm did overall. We concluded that if we were going to use a diaphragm design, it would be most advantageous to use the cylindrical compressive design (ruling out the other two). The final decision between the two implantable designs was thought to best be determined in conjunction with choosing the driver, as the driver would play a large role in the capabilities of the implanted portion. Therefore, the air-drive dual piston and cylindrical compressive diaphragm design continued on to the next round.

The Implantable Portion:

Extra Analysis: Implantable Designs	Air-driven dual piston	Circular Compressive Diaph.	Cylindrical Expansive Diaph.	Cylindrical Compressive Diaph.	Center-to-Side fan
Energy	87.7%	66.2%	80.0%	86.2%	61.5%
Manufacturability	57.8%	85.6%	60.0%	80.0%	67.8%

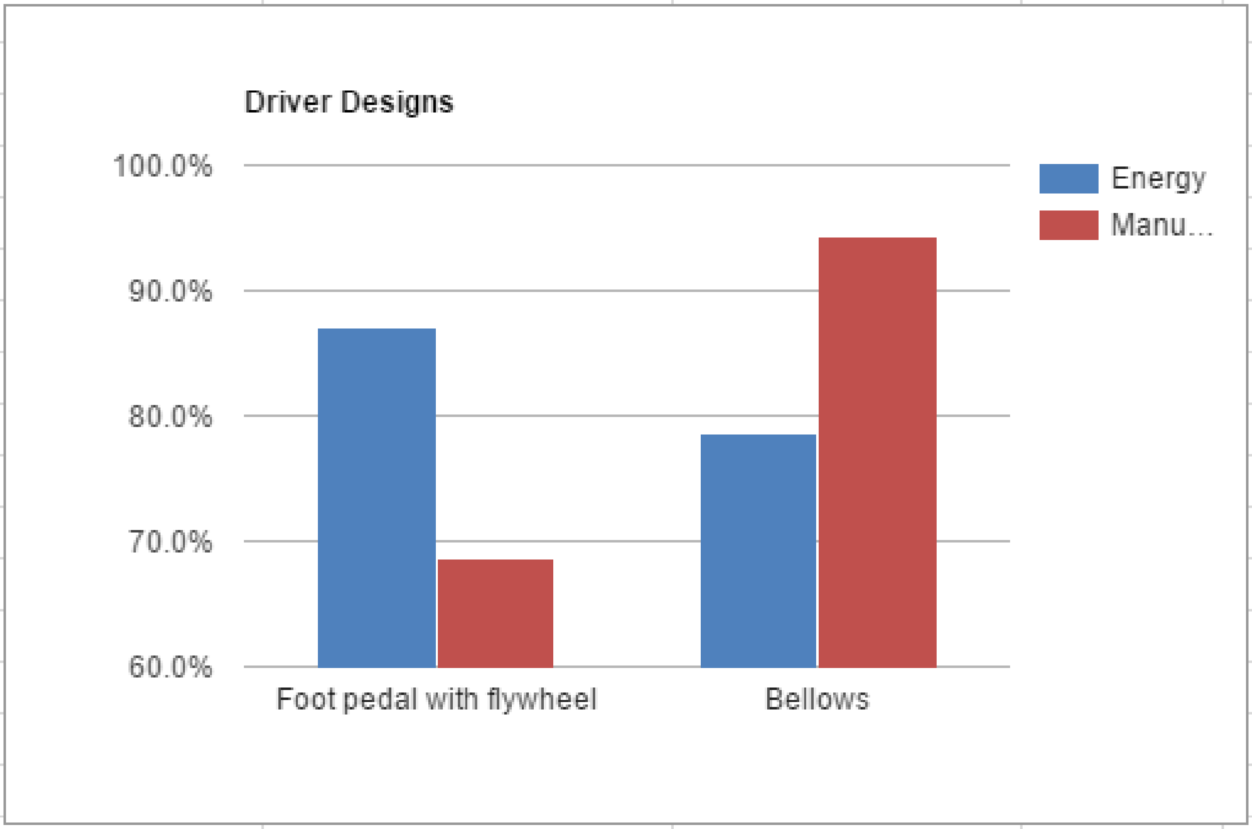


Final Selection

The merits of the two driver designs and two implantable designs were discussed. For the implantable portion, the cylindrical compression diaphragm seemed like the best choice. However, once the idea was looked into more deeply, it was found that there were far more complexities than originally thought. For this reason, the air-driven dual piston was selected as the winner of the implantable portion. Based on this information, we chose the foot pedal and flywheel as our driver design. The reason for this was that both the bellows and the driver design looked promising, and we were confident that with time we could manufacture both well. However, we felt that the foot pedal would be a better choice because it had a greater capacity for output and thus would potentially be more beneficial in the class competition and in real life.

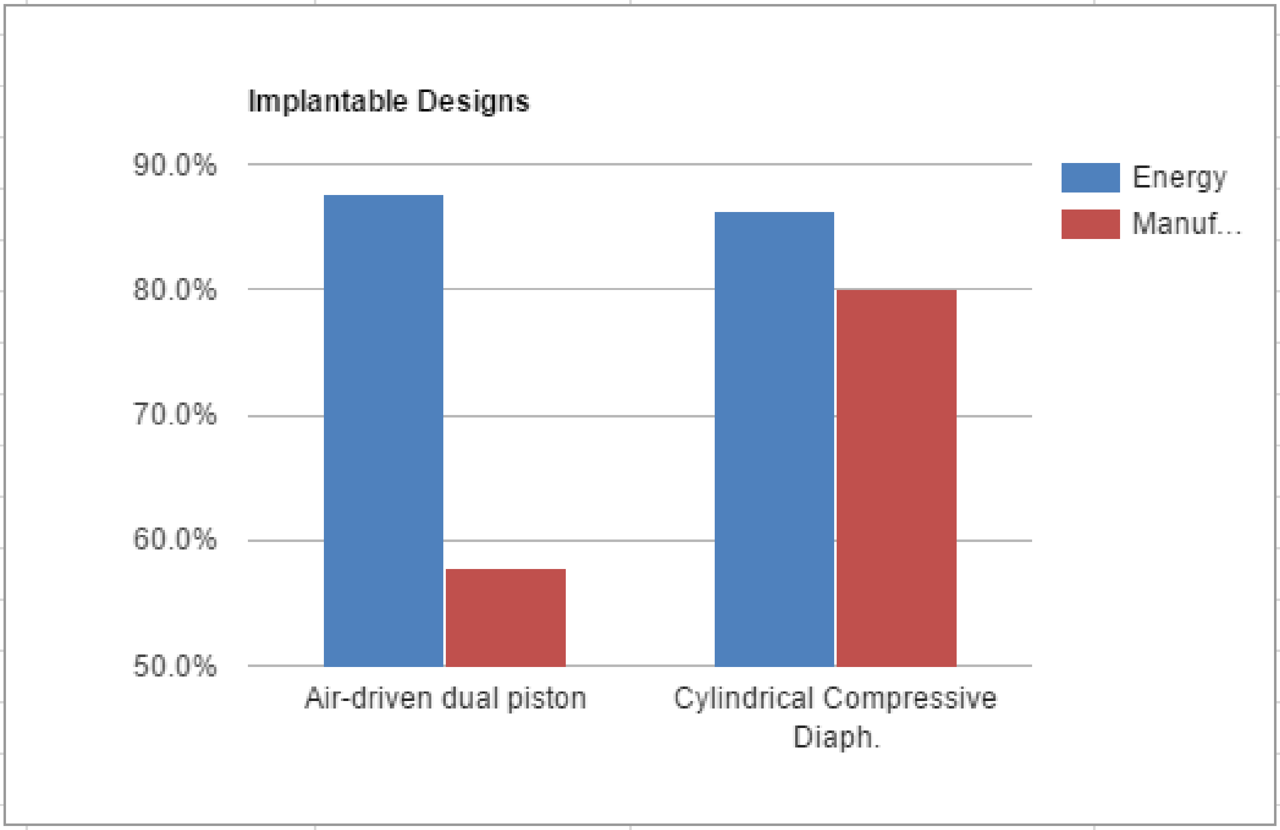
The chief technical risks for the chosen designs are that the blood bags in the drivers could get stuck between the piston heads and chamber walls, that the valves would not provide sufficient unidirectional net flow and inhibit flow in the reverse direction, and that the connection between the foot pedal and the flywheel may stop or slow the flywheel if not timed right, rather than furthering the spin. Another factor that needs to be looked into is whether or not the 3D printed plastic can be considered waterproof on its own, or if an additional sealant is required.

The External Driver:



	Foot pedal with flywheel	Bellows
Energy	87.1%	78.6%
Manufacturability	68.6%	94.3%

The Implantable Portion:



	Air-driven dual piston	Cylindrical Compressive Diaph.
Energy	87.7%	86.2%
Manufacturability	57.8%	80.0%