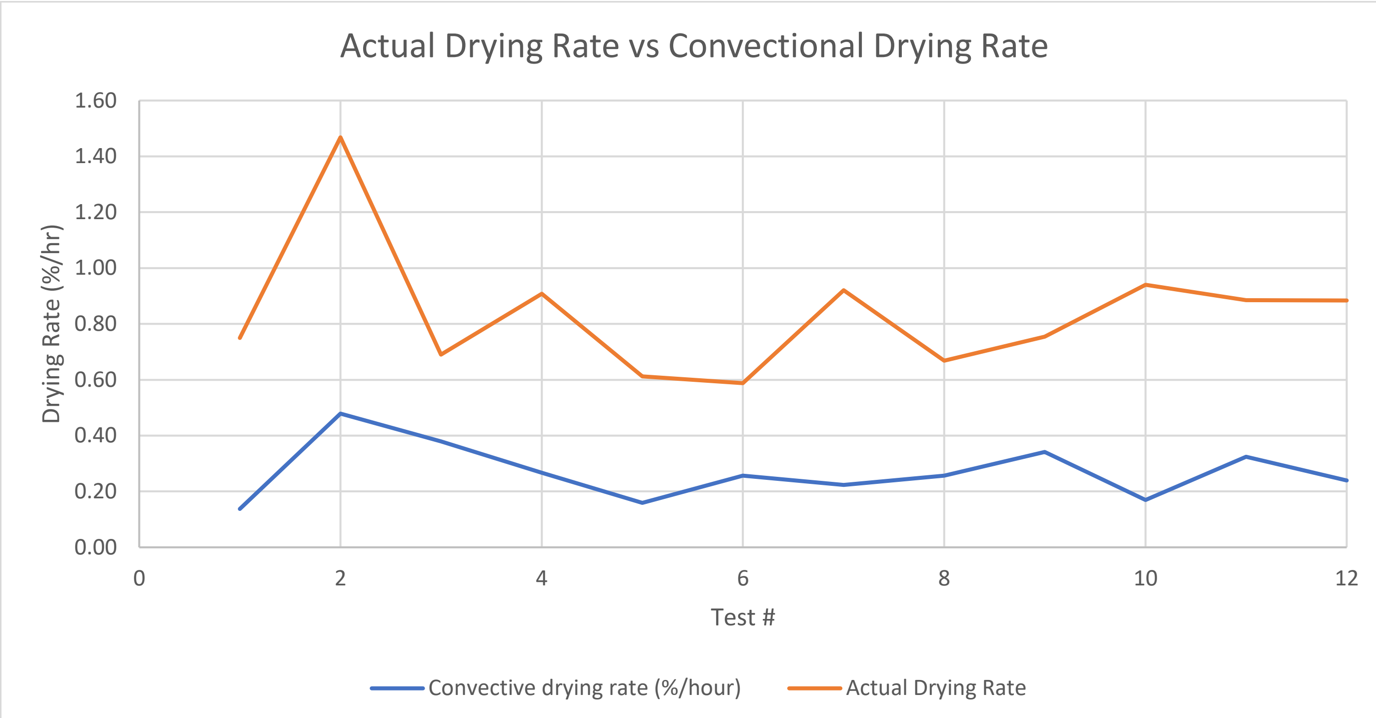
This is a brief overview of the DryMAX 293 cubic foot capacity system. This prototype is used for testing the veracity of RF drying upscaling.

Below is a test by test comparison of the actual drying rate of this dryer vs a convection model of the same design.



Below is a chart of the data above. The far right column shows the multiplier effect the RF has on the drying rate across various tests.

Test	**Convective drying rate (%/hour)**	**Actual Drying Rate (%/hour)**	**Multiplier effect of RF implementation**
1	0.14	0.75	5.45
2	0.48	1.47	3.07
3	0.38	0.69	1.82
4	0.27	0.91	3.40
5	0.16	0.61	3.83
6	0.26	0.59	2.29
7	0.22	0.92	4.12
8	0.26	0.67	2.60
9	0.34	0.75	2.21
10	0.17	0.94	5.54
11	0.32	0.89	2.73
12	0.24	0.88	3.69
Average	**0.27**	**0.84**	**3.40**

The convective model was created using the cross-flow equation below. This system is dependent on experimentally-defined variables; nothing here is determined by conjecture, but instead by the results of the test. This makes this model a very good fit for isolating the convective drying effect of our system. Below is the empirical formula used for this convection model.

$$\frac{dX}{dt} = \frac{Gc_s(LMTD)\left(1 - e^{-\frac{haz}{Gc_s}}\right)}{P\lambda_w z}$$

$$G = mass\ flow\ rtae\ of\ dry\ air\left(\frac{lb}{min * ft^2}\right) = \frac{M_{air}}{(min * ft^2)}$$

$$c_s = specific\ heat\ of\ dry\ air\left(\frac{BTU}{lb_m}\right) = 1.005 * 1.88H$$

$$LMTD = \frac{(T_1 - T_w) - (T_2 - T_w)}{\ln\left(\frac{T_1 - T_w}{T_2 - T_w}\right)}$$

$$T_1 = Inlet\ air\ temperature$$

$$T_2 = Outlet\ air\ temperature$$

$$T_w = Wet\ bulb\ temperature\ (outlet\ based)$$

$$h = convective\ heat\ capacity\left(\frac{BTU}{ft^2}F^o\right) = \frac{0.151G^{0.59}}{D_p^{0.41}}$$

$$D_p = diamter\ of\ granular\ solid$$

$$a = geometry\ factor(unitless) = \frac{6(1 - \varepsilon)}{D_p}$$

$$\varepsilon = void\ fraction(unitless)$$

$$P = pressure = 1\ atm$$

$$\lambda_w = latent\ heat\ of\ water\left(\frac{BTU}{lb_m}\right)$$

$$z = bed\ depth(ft)$$

It is important to note that because the convection model is based on outflow data collected during RF tests, the hypothetical convective drying rate is likely slightly inflated. In other words, the "multiplier" effect of the RF is actually likely higher than stated in the chart above. Purely convective tests are needed to prove this.

Cost Analysis

Below is a cost analysis of the tests performed. The conservative estimate is based on the low estimation of the dryer’s capacity (low moisture wet corn 22%, low bushel weight, lower bed volume), and the optimistic estimate is based on the high estimation of the dyer’s capacity (high moisture wet corn 27%, high bushel weight, higher bed volume).

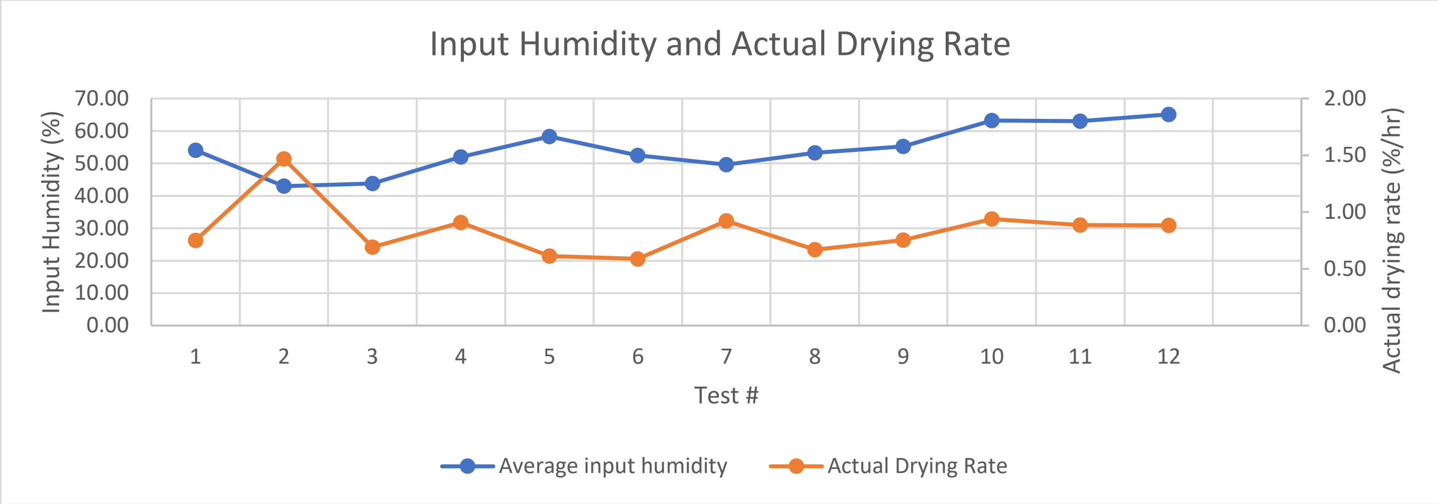
Conservative Estimate

Test	%/hour	Bushels	kwh	Pounds of water removed	cents/pound of water removed	cents/points/bushel	Pounds of water removed/kwh
1	0.7	233.76	48.0	1570.87	0.27	0.15	32.73
2	1	233.76	40	1963.59	0.18	0.12	49.09
3	1.4	233.76	85	1963.59	0.38	0.26	23.10
4	1.5	233.76	21.6	1701.78	0.11	0.07	78.79
5	2.4	233.76	27.5	1832.68	0.13	0.09	66.64
6	1	253.04	54	1275.30	0.37	0.16	23.62
7	1.6	253.04	29.6	850.20	0.30	0.09	28.72
8	2.6	253.04	30	1417.00	0.18	0.09	47.23
9	1.2	253.04	87.5	1983.80	0.39	0.25	22.67
10	1.6	253.04	68	1983.80	0.30	0.20	29.17
11	1.2	253.04	45.8	1275.30	0.31	0.13	27.84
12	2.25	253.04	25.5	1275.30	0.17	0.07	50.01
Average	**1.47**	**244.27**	**48.82**	**1619.81**	**0.27**	**0.15**	**39.06**

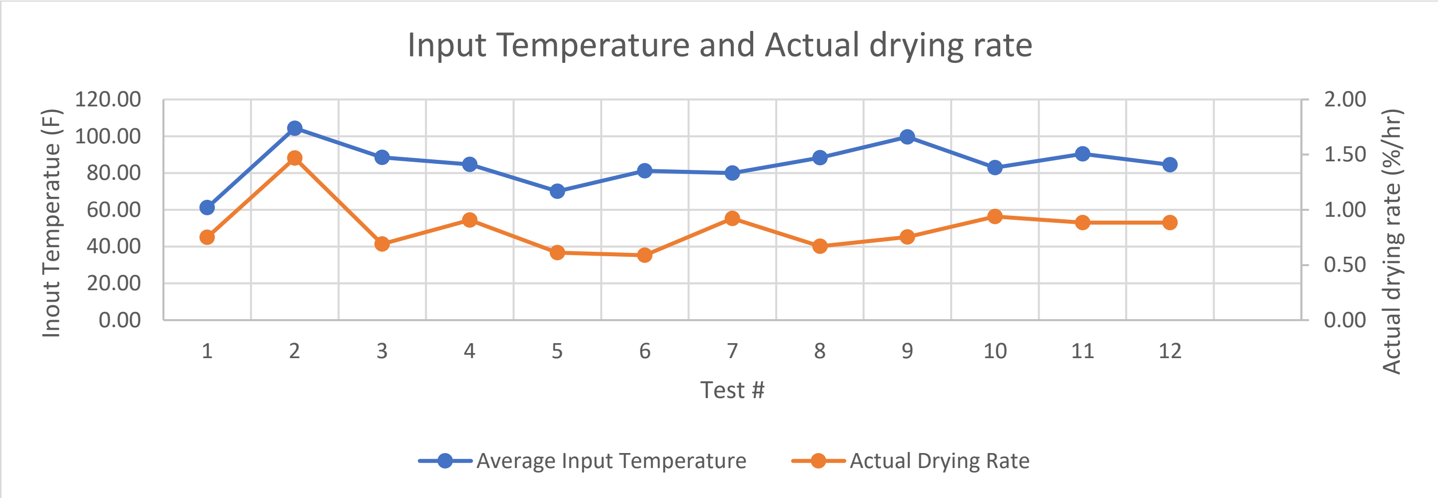
Optimistic Estimate

Test	%/hour	Bushels	kwh	Pounds of water removed	cents/pound of water removed	cents/points/bushel	Pounds of water removed/kwh
1	0.7	280.36	48.0	1884.00	0.22	0.12	39.25
2	1	280.36	40	2355.00	0.15	0.10	58.88
3	1.4	280.36	85	2355.00	0.32	0.22	27.71
4	1.5	280.36	21.6	2041.00	0.09	0.06	94.49
5	2.4	280.36	27.5	2198.00	0.11	0.07	79.93
6	1	305.59	54	1540.17	0.31	0.13	28.52
7	1.6	305.59	29.6	1026.78	0.25	0.07	34.69
8	2.6	305.59	30	1711.30	0.15	0.07	57.04
9	1.2	305.59	87.5	2395.82	0.32	0.21	27.38
10	1.6	305.59	68	2395.82	0.25	0.16	35.23
11	1.2	305.59	45.8	1540.17	0.26	0.11	33.63
12	2.25	305.59	25.5	1540.17	0.14	0.06	60.40
Average	**1.47**	**294.12**	**48.82**	**1949.37**	**0.22**	**0.12**	**46.98**

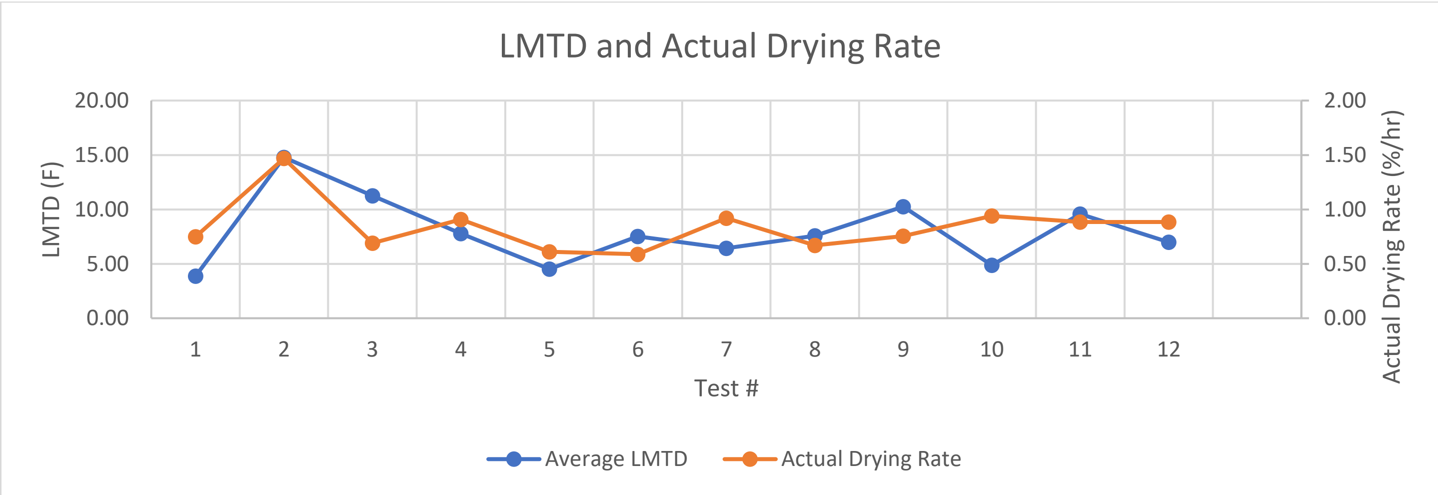
Various Relationships Between Drying Rate and External Factors



There is an inverse relationship between input humidity and the drying rate. Higher humidity has slightly adverse effects on the drying rate, mostly due to the input air's ability to carry the released moisture from the bed. Higher CFM will likely solve this.



There is a somewhat proportional relationship between input temperature and drying rate. Higher temperature air has a higher moisture carrying capacity, so the drying rate is generally increased when the ambient temperature is hotter.



There is no real relationship between the log mean temperature difference and the actual drying rate, though it does trend proportionally. This means that the temperature difference from inlet to outlet has no bearing on the drying rate.

The chart below shows the viability of upscaling this technology. Lab-scale units are compared to the upscaled 293 cubic feet prototype. There is a clear progression of efficiency and cost reduction as the scale moves up. The values shown are averages across many tests.

Unit size (ft^3)	**Pounds of water removed per hour**	**Pounds of water removed per kWh**	**Cents per pounds of water removed**
4.5	10.06	4.49	1.98
18	24.76	9.53	1.32
293	198.89	39.97	0.26

The chart below shows the cost comparison and emissions as compared to propane-drying systems for both the lab-scale unit and the prototype.

S. No.	**Goal**	**Specific energy consumption kWh/kg (moisture)**	**Specific energy consumption reduction compared to baseline technology**	**Carbon intensity ton CO_2e/kg product**	**Carbon intensity reduction compared to baseline technology**	**Drying cost $/kg water removed**	**Drying cost reduction compared to baseline technology**
1	Drymax’s lab dryer	0.4013	72.6%	0.000009	87.0%	0.041	63.7%
2	Drymax’s upscaled dryer	0.0137	99.1%	0.000002	97.0%	0.002	98.2%
3	Baseline-Propane dryer	1.4600 (Mean value)	-	0.000069	-	0.113	-