Supporting Information

Sustainable Value Recovery of NdFeB Magnets: A Multi-Objective Network Design and Genetic Algorithm

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Number of tables: 3

The specific input parameter values for our analysis are listed in Table S1. We assumed 10 years of operation for the proposed NdFeB magnet recycling infrastructure. The prices and costs were assumed to increase by 1.76% a year based on the U.S. average inflation rate in the past 10 years.[1] The only exception is the transportation cost, which has been decreasing over time.[2]

Table S1. Input parameter values and data sources.[3]

Notation	Value	Reference
p_{NdFeB}^{t}	\$180/kg NdFeB magnet	Benecki (2013)[4]
$p_{l(k)}^{t}$	\$17.6/kg PCB, \$2.2/kg others	Cong, et al. (2017)[5]
$w_{l(k)}$	HDD: 7.3% PCB, 88.4% others; EV motor: 97% others	Mohite and Zhang (2005)[6] Burress, et al. (2011)[7]
$w_{NdFeB,k}$	4.3% for HDD, 3% for EV motor	Burress, et al. (2011)[7] Nguyen, et al. (2017)[8]
ac_{k}^{t}	\$0/kg HDD; \$0.5/kg EV motor	Cong, et al. (2015)[9]
tc_{ij}^{t}	$d_{ij} \cdot$ \$0.00022/kg	Torrey and Murray (2016)[2]
tc_{jr}^{t}	$d_{jr} \cdot$ \$0.00022/kg	Torrey and Murray (2016)[2]
tc_{rs}^{t}	$d_{rs} \cdot$ \$0.00022/kg	Torrey and Murray (2016)[2]
sc_{j}	\$3,000,000 per set-up	Estimates from industry
sc_{r}	\$20,000,000 per set-up	Estimates from industry
$oc_{j,k}^{t}$	\$0.2/kg HDDs, \$0.5/kg EV motors on average (see Table S2)	Cong, et al. (2015)[9]
oc_{r}^{t}	\$14.98/kg on average (see Table S2)	Wulf, et al. (2017)[10]
η	70%	Sprecher, et al. (2014)[11]
$q_{j}^{\max}$	5,000 tons of EOL products a year	Jin, et al. (2017)[3]
$q_{r}^{\max}$	250 tons of EOL NdFeB magnets a year	Jin, et al. (2017)[3]
co_{2}^{r}	99.8kg/kg of NdFeB magnet	Jin, et al. (2018)[12]
$co_{2}(d_{ij})$	$d_{ij} \cdot$ 5.18E-04kg/km/kg of EOL product	Wernet, et al. (2016)[13]
$co_{2}(d_{jr})$	$d_{jr} \cdot$ 5.18E-04kg/km/kg of NdFeB magnet	Wernet, et al. (2016)[13]
$co_{2}(d_{rs})$	$d_{rs} \cdot$ 5.18E-04kg/km/kg of NdFeB magnet	Wernet, et al. (2016)[13]
$co_{2}(d_{China})$	0.125kg/kg of NdFeB magnet (i.e.,11000km*1.14E-05kg CO_2/km/kg of freight)	Wernet, et al. (2016)[13]

Table S2 shows more data on the EOL product supply, operating costs, and social support ranking used in our analysis for each state.[3,14] The market supply of EOL products was projected to change: EOL HDD supply would decrease by 1% a year,[15] while EOL EVs would increase by 32% a year.[16]

Table S2. EOL product supply and operating costs (shown for the first year only),[3] and social support ranking of each state.[15]

No.	State	Latitude, Longitude	HDDs (kg/yr.)	EV motors (kg/yr.)	*OC* of HDD[1] ($/kg)	*OC* of EV[1] ($/kg)	*OC* of NdFeB[1] ($/kg)	ss_j, ss_r (rank)
1	**CA**	37.1841, -119.4696	899,839	96,726	0.23	0.58	17.46	19
2	**TX**	31.4757, -99.3312	638,773	6,387	0.20	0.50	15.07	45
3	**FL**	28.6305, -82.4497	472,557	7,586	0.18	0.45	13.38	37
4	**NY**	42.9538, -75.5268	452,677	7,622	0.22	0.55	16.46	25
5	**PA**	40.8781, -77.7996	293,089	3,302	0.20	0.50	15.07	11
6	**IL**	40.0417, -89.1965	293,486	4,235	0.22	0.54	16.13	16
7	**OH**	40.2862, -82.7937	266,269	2,348	0.18	0.46	13.83	38
8	**GA**	32.6415, -83.4426	236,374	9,563	0.19	0.46	13.87	42
9	**NC**	35.5557, -79.3877	232,623	2,344	0.17	0.43	12.96	47
10	**MI**	44.3467, -85.4102	227,614	4,538	0.18	0.46	13.82	21
11	**NJ**	40.1907, -74.6728	205,059	4,344	0.26	0.65	19.58	10
12	**VA**	37.5215, -78.8537	192,848	2,685	0.24	0.60	17.94	43
13	**WA**	47.3826, -120.4472	167,083	8,118	0.23	0.58	17.35	40
14	**AZ**	34.2744, -111.6602	158,900	3,018	0.19	0.47	13.93	23
15	**MA**	42.2596, -71.8083	156,166	3,419	0.26	0.64	19.13	30
16	**TN**	35.8580, -86.3505	152,484	1,271	0.17	0.43	12.79	32
17	**IN**	39.8942, -86.2816	152,068	1,268	0.18	0.46	13.67	36
18	**MO**	38.3566, -92.4580	139,687	1,165	0.18	0.45	13.59	24
19	**MD**	39.0550, -76.7909	137,932	3,107	0.27	0.68	20.52	18
20	**WI**	44.6243, -89.9941	132,482	1,105	0.20	0.50	15.06	22
21	**CO**	38.9972, -105.5478	127,022	3,196	0.23	0.58	17.31	44
22	**MN**	46.2807, -94.3053	126,549	1,055	0.23	0.57	17.18	34
23	**SC**	33.9169, -80.8964	113,738	948	0.17	0.43	12.81	28
24	**AL**	32.7794, -86.8287	111,495	930	0.16	0.41	12.14	6
25	**LA**	31.0689, -91.9968	107,331	895	0.17	0.41	12.41	9
26	**KY**	37.5347, -85.3021	101,721	848	0.16	0.41	12.23	12
27	**OR**	43.9336, -120.5583	93,846	4,278	0.20	0.49	14.64	33
28	**OK**	35.5889, -97.4943	89,951	750	0.18	0.44	13.16	29
29	**CT**	41.6219, -72.7273	81,993	1,927	0.26	0.64	19.31	7
30	**IA**	42.0751, -93.4960	71,865	599	0.20	0.50	14.85	35
31	**UT**	39.3055, -111.6703	69,952	583	0.23	0.57	17.04	48
32	**MS**	32.7364, -89.6678	68,519	571	0.15	0.37	11.00	3

[1] *OC* stands for operating cost.

33	**AR**	34.8938, -92.4426	68,508	571	0.15	0.38	11.38	15
34	**NV**	39.3289, -116.6312	67,403	562	0.19	0.47	14.22	17
35	**KS**	38.4937, -98.3804	66,652	556	0.19	0.49	14.57	20
36	**NM**	34.4071, -106.1126	47,709	398	0.16	0.41	12.32	4
37	**NE**	41.5378, -99.7951	43,722	365	0.20	0.50	14.91	46
38	**WV**	38.6409, -80.6227	41,980	350	0.15	0.38	11.36	1
39	**ID**	44.3509, -114.6130	38,587	322	0.17	0.44	13.08	31
40	**ME**	45.3695, -69.2428	30,525	255	0.19	0.46	13.92	2
41	**NH**	43.6805, -71.5811	30,601	255	0.25	0.63	18.95	13
42	**RI**	41.6762, -71.5562	24,219	202	0.21	0.52	15.50	8
43	**MT**	47.0527, -109.6333	23,901	199	0.18	0.45	13.44	26
44	**DE**	38.9896, -75.5050	21,827	182	0.22	0.55	16.60	27
45	**SD**	44.4443, -100.2263	19,841	165	0.19	0.48	14.42	39
46	**ND**	47.4501, -100.4659	17,377	145	0.22	0.56	16.70	41
47	**VT**	44.0687, -72.6658	14,319	119	0.21	0.51	15.40	5
48	**WY**	42.9957, -107.5512	13,423	112	0.22	0.55	16.57	14

Table S3 shows the potential points of sale for recovered NdFeB magnets. A large vehicle motor manufacturer was selected that has six branch locations in the U.S. (i.e., New York (2 locations), Ohio, Alabama, Michigan, and Oklahoma). Total demand was assumed to be 250 tons a year and was equally distributed to all six loctions.

Table S3. Demand for recovered NdFeB magnets.

State	Latitude, Longitude
NY	43.026481, -78.805871
OH	39.788988, -84.174326
AL	31.282441, -85.449553
MI	42.996869, -84.206350
OK	36.099766, -95.865721
NY	43.995143, -75.941623

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