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## A Study on the Analysis of Solar Consumer Perception Using Big Data

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### Abstract

Among eco-friendly energy, solar energy is one of the renewable energy sources that is developing in the spotlight in many countries. In line with this, the Korean government and local governments are carrying out projects to provide subsidies for the distribution of household solar power, raising the spread of household solar power and awareness. However, due to the lack of research on consumer perception of household solar power, this study investigated the perception of household solar power from 2015 to 2022 by setting the central word as solar power. As a result, 2016 had the highest number of collections, and when the top 50 words for each year were analyzed, it was confirmed that words related to the installation and maintenance of household solar power dominated. And through CONCOR analysis, a total of four were derived: solar energy recognition, renewable and eco-friendly energy recognition, solar government policies, solar companies, and perceptions of households. Through emotional analysis, it was confirmed that 2021 had the most positive data. As a result, consumer perception of household solar power is positive based on what was mentioned above, but research on how to use negative opinions on waste control and installation and maintenance should be conducted.

**Keywords:** Big data, Social Media, Sensitivity Analysis, Solar Power, Consumer Awareness

### 1. INTRODUCTION

The power generation of solar energy among eco-friendly energy has spread widely to many consumers, regardless of research institutes and smart cities [1]. It has been confirmed that the awareness of solar energy among renewable energy is high worldwide. For example, in the case of the United States, solar power (84%) and wind power (77%) were highly preferred, and in the case of the United Kingdom, solar preference was 86%, and 76%, respectively, that it was necessary to expand further. And in the case of Japan, Korea's neighboring country, the preference was investigated as solar power (75.5%) and wind power (62.8%) as future energy sources [2]. Accordingly, the Korean government and local governments are recently subsidizing household solar power, increasing awareness and efficiency of household solar power. And household solar power is attracting attention from many consumers due to its relatively simple and easy installation [3,5]. In

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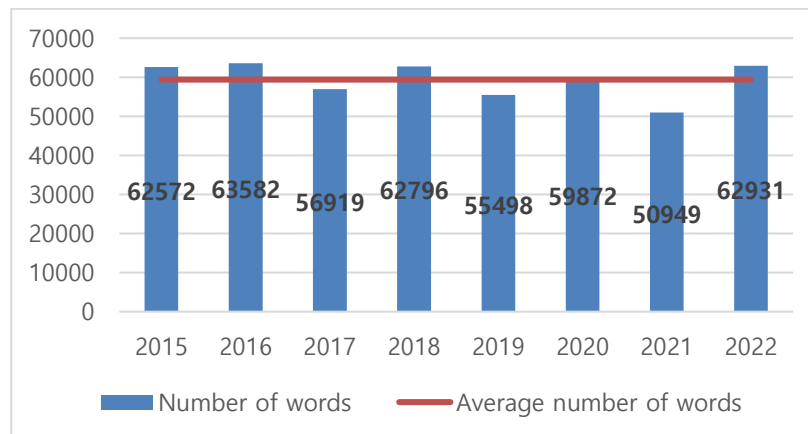


words								
<b>Ratio (Average)</b>	105.36 %	107.06 %	95.84 %	105.74 %	93.45 %	100.81 %	85.79 %	105.96 %
<b>year-on-year</b>		101.61 %	89.52 %	110.33 %	88.38 %	107.88 %	85.10 %	123.52 %

Although there is no significant difference from year to year, the number of collections for solar power was relatively small in 2017, 2019, and 2021. The year with the highest number of collections was 2016 and the year with the lowest number of collections was 2021. In 2016, the increase was the highest at 107.06%, compared to the previous year, and the decrease was the lowest at 85.19% in 2021. When confirmed through the original data, it is believed that in 2016, the government expanded the support project to support solar power to homes (Korea Energy Agency, 2018), and the number of collections for solar power was the largest.

Next, in 2017, solar power was in the spotlight as awareness of homes and consumers increased due to solar power, but it was confirmed through the original big data that solar panels, sites, and facilities were unable to install solar power. In addition, in 2021, it was confirmed that the number of collections for solar power was the lowest due to store income and basic living difficulties due to the deepening of the pandemic caused by Corona.

In 2022, as the pandemic caused by Corona gradually intensified, more consumers tried to save electricity bills as the government eased regulations for store income. As a result, the number of collections is high as the awareness of solar panels gradually comes to life and consumer awareness of solar power increases. Figure 1 below is a picture related to the number of collections and average values for each year.



**Figure 1. Number of words and average values for each year**

Next, a total of eight years were surveyed from 2015 to 2022, and words were considered up to 91.8% of the accumulated frequency of words. Table 1 shows the words in the ranking up to 50 and their frequencies for each year. In general, the top 10 words from 2015 to 2022 - solar power, power generation, energy, installation, electricity, power plant, solar, facility, industry, and module - were similar. However, when checked centering on the word "home", it was ranked 36th in 2015, 13th in 2016, 42nd in 2017, and 31st in 2018. And from 2019 to 2022, it was not included in the top 50 words. In other words, when checked with the word "home", the ranking fluctuation was large, and when checked by year, it was confirmed that it was included in the top words from 2015 to 2018, but after that, it was eliminated from the top words.

When this situation was confirmed from the original text data, it was found that as the government expanded the implementation industry for the dissemination of homes, many consumers received subsidies and installed solar panels on the rooftops of buildings and windows of homes to reduce electricity bills. Next, the word "renewable" was a word that steadily increased in ranking from 2015 to 2022, rising to 45th in 2015 but rising to 17th in 2021 and 21st, down sharply in 2022. This confirmed that consumers have increased their interest in renewable energy for solar power, and as a result, a new word such as "carbon" has emerged.

Table 2. 50 words analyzed for each year

Year Rank	2015		2016		2017		2018		2019		2020		2021		2022	
	Keyword	Freq	Keyword	Freq	Keyword	Freq	Keyword	Freq	Keyword	Freq	Keyword	Freq	Keyword	Freq	Keyword	Freq
1	solar power	18546	solar power	19308	solar power	17871	solar power	20955	solar power	17952	solar power	20381	solar power	16573	solar power	20244
2	Development	4881	Development	5295	Development	4753	Development	6561	Development	5012	Development	5016	Development	3977	Development	4047
3	Energy	4361	Energy	4443	Energy	3210	Energy	3562	Energy	3178	Energy	3545	Energy	3072	Installation	3652
4	Installation	2637	Installation	3147	Installation	3120	Installation	3388	Installation	2976	Installation	2807	Installation	2884	Energy	3623
5	electricity	1922	electricity	1908	a power plant	2012	a power plant	2223	a power plant	1951	a power plant	2087	Panel	1276	a power plant	2120
6	a power plant	1893	a power plant	1716	electricity	1493	electricity	1424	electricity	1159	Panel	1370	electricity	1267	electricity	1420
7	Sun	1308	Industry	1175	facility	958	Facilities	1125	Modules	1038	Modules	1150	a power plant	1239	Panel	1322
8	Facilities	1188	Sun	1170	Industry	934	Panel	963	Panel	939	electricity	1070	Modules	1096	Facilities	1191
9	Industry	1174	Facilities	1009	Facilities	877	Price	883	Facilities	827	Hanwha	1064	Facilities	845	Relevant	1153
10	Modules	1161	market	981	Area	812	Modules	829	Industry	820	Facilities	931	Charging	808	Modules	1054
11	market	1039	Modules	959	Sun	769	Industry	787	Development	716	Development	825	Use	784	Industry	934
12	Utilization	900	Utilization	914	Scale	738	Housing	771	Sun	671	Charging	781	Industry	700	Roof	897
13	skill	877	home	904	skill	671	Profits	721	company	660	Use	778	skill	645	Use	810
14	Use	843	Use	869	Charging	667	Development	718	Efficiency	599	Industry	669	Housing	643	electric power	782
15	Hanwha	840	skill	850	Use	656	Sun	701	skill	597	wind power	661	electric power	632	Building	763
16	Charging	800	Charging	819	Panel	655	Use	687	market	593	skill	633	wind power	632	Corporation	755
17	Housing	761	electric power	801	Modules	640	electric power	684	Housing	581	electric power	616	Playback	592	company	700
18	electric power	740	Construction	734	wind power	633	Area	654	the prime minister	579	Article	614	Development	574	Development	695
19	Article	728	Corporation	729	Housing	628	company	615	the prime minister	574	company	609	Saemangeum	570	Housing	685
20	Production	706	Production	703	Mini	620	Research	602	Use	569	Sun	582	the prime minister	564	Government	667
21	Corporation	696	Development	696	Investment	611	Playback	592	Corporation	561	construction work	578	Research	541	Playback	653
22	Development	668	Price	678	Development	586	Government	587	Government	543	Area	576	Sun	525	Production	637
23	a battery	641	Housing	673	Production	577	facility	585	facility	542	Research	576	Government	515	Scale	637
24	Research	637	wind power	666	Government	577	skill	571	Charging	536	Housing	556	company	468	parcel out	630
25	Scale	636	Scale	640	Economy	576	Charging	568	Area	524	facility	523	Production	462	skill	626
26	sale	601	Area	623	Utilization	563	Scale	550	Construction	521	Saemangeum	519	Corporation	454	wind power	626
27	facility	590	Research	618	Price	555	Production	534	Playback	517	Playback	510	Scale	452	facility	600
28	Economy	590	Panel	617	electric power	552	Domestic	530	Scale	503	Construction	491	Eco-friendly	431	Sun	589
29	the product	580	facility	604	market	551	Corporation	519	Production	486	the prime minister	488	Area	428	Solution	586
30	Efficiency	579	a battery	577	the prime minister	514	market	509	construction work	485	Scale	487	Carbon	424	Carbon	579
31	Price	572	solar heat	521	Playback	510	home	501	Research	481	Production	486	facility	409	Research	572
32	solar heat	556	Economy	520	Corporation	506	parcel out	498	wind power	481	Inverter	478	Efficiency	394	Investment	572
33	wind power	544	Efficiency	511	Center	496	wind power	468	propulsion	472	Profits	473	Battery	392	Area	568
34	Supply	526	Investment	506	supply	493	construction work	465	Investment	472	market	468	Roof	391	Charging	536
35	Area	518	sale	492	the product	467	Cost	462	parcel out	471	Investment	458	Building	391	Price	515
36	home	509	Article	486	Research	462	Investment	450	Utilization	462	News	457	Inverter	387	Power generation	477
37	Investment	501	the product	473	Solar	455	Utilization	447	Profits	453	Corporation	451	Utilization	370	Permission	476
38	Construction	497	Solar	467	propulsion	445	Permission	438	News	446	Building	440	Price	363	Economy	471
39	Construction	477	Battery	454	Profits	437	Korea Electric	425	Domestic	426	Solution	423	Profits	357	market	466
40	Panel	473	roof	418	site	432	the product	410	Article	414	Efficiency	423	Power generation	335	News	459
41	Design	449	Government	416	home	423	Efficiency	408	Construction	408	Government	414	Construction	326	Eco-friendly	453
42	construction work	447	Playback	415	Battery	405	Article	404	Supply	405	Roof	413	market	319	Contract	434
43	Battery	403	apartment	401	individual	397	Construction	392	Cost	388	Hydrogen	386	the product	314	construction work	433
44	an electric generator	399	an electric generator	401	Resident	394	Solar	392	Permission	382	Utilization	386	propulsion	306	Utilization	431

45	Playback	385	Cost	401	Cost	380	Environment	385	electron	373	Resident	383	Analysis	306	Inverter	427
46	Entrepreneur	379	Construction	399	a battery	379	Economy	382	Solar	370	the product	382	News	305	Efficiency	406
47	Environment	365	Roof	377	Construction	370	propulsion	379	Price	358	Expansion	373	sale	305	Analysis	402
48	Management	360	Analysis	368	apartment	368	Entrepreneur	367	Environment	352	sale	366	Management	304	Article	387
49	Eco-friendly	358	News	365	nuclear facility	364	Professional	364	Professional	340	supply	362	construction work	303	Battery	387
50	Expansion	331	Eco-friendly	365	construction work	357	Device	361	supply	335	Battery	357	Economy	299	factory	382

Next, through centrality analysis, I would like to confirm the positions of the words for the central word "solar". At this time, the analysis was conducted by integrating all words during the collection period. In the integrated solar centrality analysis, power generation, necessity, new and renewable energy, government, technology, price, investment, power generation, and eco-friendliness were shown centering on solar power, and surrounding words such as inquiry, scale, energy, renewable energy, wind power, policy, company, profit, roof, support, and market appeared. CONCOR analysis was conducted to more accurately how words are clustered around solar power. Figure 2 below is an integrated solar centrality analysis.

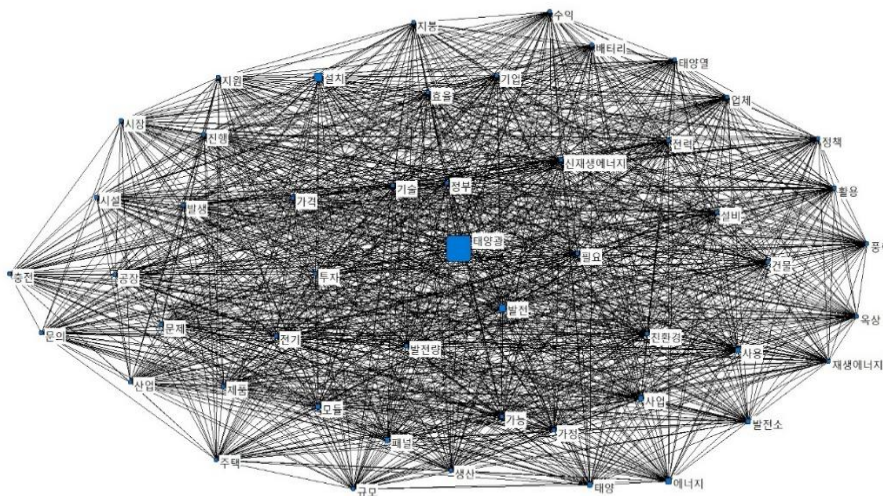


Figure 2. Integrated Solar Centrality Analysis

It was confirmed that when divided into level 2 based on the dendrogram, it was divided into 4 clusters. Therefore, in the CONCOR analysis, the cluster was divided into 4 groups. Cluster 1 was confirmed to appear as the perception of solar power Prior research, Seung Cook Choi, & Yeol Hee Lee (2016). It was determined through the study on how to boost solar power for energy conversion, and cluster 2 confirmed that words appeared because solar power is renewable and eco-friendly energy, Oh Eun-sung (2024), a prior researcher. A strategy for implementing community photovoltaic energy for the smart energy community considering that it was determined through fairness. Next, cluster 3 was confirmed to appear as the perception of the government about solar power, Prior research, Tae-Hyun Kim (2019). It was determined An Economic Analysis of a Low-Voltage Residential Electricity Consumer at a Detached House When Renting a Photovoltaic Generator. And cluster 4 confirmed that the words about companies and assumptions about solar power are clustered. Cluster 4 is one cluster in the figure 는 Prior research, Korea Energy Information Cultural Foundation(2020), It was determined Results of Energy Source Awareness Survey by Major Countries, but one in blue through two circles is represented as the solar perception of the company and the other in the solar perception of the home.

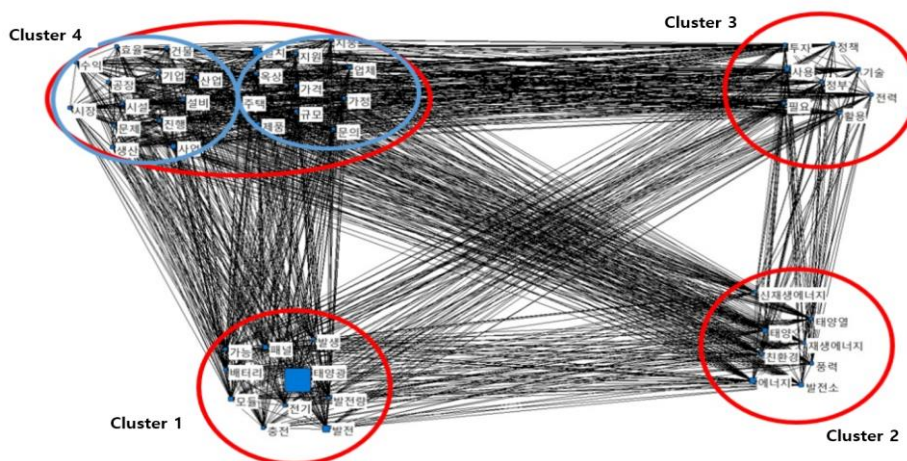


Figure 3. Integrated Solar CONCOR Analysis

Next, to analyze consumers' perceptions of solar power in detail, we would like to add the diversity of this paper by conducting an additional emotional analysis. Positive and negative opinions were divided and confirmed for easy analysis of solar power, and positive and negative opinions for each collection period were divided and confirmed through the original text data. Emotional frequency represents the total number of cases based on positive and negative, and the frequency ratio was derived through the emotional intensity ratio from the total original data. The emotional frequency ratio represents the ratio based on positive and negative, and TEXTOM's self-produced emotional word vocabulary dictionary has three words of interest/liked/joy in the category of positive/negative.

There are six words of pain/sadness/fury/fear/surprise/refusal in the negative keyword, and in the word joy, numerous words expressing joy were classified by dividing the emotional intensity from 1 point to 7 points through standardization according to their intensity. For example, if the words "happy" and "just so" are in the word "like" and "so" are given 5 points for the word "happy" and 1 point for the word "so" and even the words that fall within the same likability were analyzed by constructing a dictionary with different emotional intensity. Table 2 below is a table showing the frequency, emotional analysis ratio, and frequency ratio through emotional analysis.

Table 3. Integrated Solar Sensitivity Analysis

Year	Total Freq.	Sortation	Freq.	Emotional Intensity Ratio (%)	Freq. Ratio (%)
2015	4,819	Positive	3,682	78.15	76.41
		Negative	1,137	21.85	23.59
2016	4,654	Positive	3,420	75.21	73.49
		Negative	1,234	24.79	26.51
2017	3,869	Positive	2,942	77.62	76.04
		Negative	927	22.38	23.96
2018	3,826	Positive	2,867	76.45	74.93
		Negative	959	23.55	25.07
	3,815	Positive	2,824	75.71	74.02

<b>2019</b>		Negative	991	24.29	25.98
<b>2020</b>	3,763	Positive	2,819	76.99	76.88
		Negative	944	23.01	23.12
<b>2021</b>	3,387	Positive	2,604	79.28	76.88
		Negative	783	20.72	23.12
<b>2022</b>	4,014	Positive	2,951	75.81	73.52
		Negative	1,063	24.19	26.48

When the emotional analysis was conducted, the year when there were many positive original data was confirmed as 2021, and the year when there were many negative original data was confirmed as 2016, and in 2021, it is understood that the negative impact of households due to Corona is trying to save electricity bills through solar power. In 2016, when there were many negative opinions, many local governments confirmed that the quality of solar energy at home was lowered by too many subcontractors due to the simplification of solar installation and supply procedures implemented in 2015 due to the government's revitalization of the solar power market, such as the 2017 Korea Energy Resources Report and the original data of this paper. It was also confirmed that positive opinions have increased due to the policy on hydrogen energy as well as wind and power energy while reducing carbon emissions. Table 3 below shows the emotional frequency ratio.

Many consumers applied for the installation of solar panels as the government decided to distribute the above-mentioned solar power supply policy to their homes while making subsidies, but due to delays caused by the lack of solar supplies and panels, consumers confirmed their opinions that they had to wait a long time. The year with the second largest number of negative original data was identified as 2022, and the year before 2021, compared to the year with the largest number of positive original data, negative opinions increased significantly. When checking the original data, it was confirmed that negative opinions increased as the problem of solar power was identified in homes and buildings with solar panels installed in accordance with the government's solar power supply policy from 2015 to 2017.

#### 4. CONCLUSION

The development of solar energy among eco-friendly energy raises awareness of household solar installation and many consumers install and use solar power in each home. However, research on household solar power and consumer perception is insufficient. Therefore, to investigate the perception of household solar power, this paper attempted to investigate the perception of household solar power by using big data shown on SNS and news.

According to the analysis using solar power as the central word, the number of solar collections by year is not significantly different, but the number of solar collections was relatively high in 2017, 2019, and 2021, the highest in 2016, the lowest in 2021, and in 2016, the government expanded support projects to support solar power to homes (Korea Energy Agency, 2018), showing the largest collection of solar power.

Next, we analyzed the top 50 words that analyzed a total of 8 years from 2015 to 2022. In general, from 2015 to 2022, the top 10 words appeared similar, but it was confirmed that the words about installation and maintenance appeared dominant in-home sunlight.

Next, in the CONCOR analysis, the cluster was divided into 4 groups and the analysis was conducted. Cluster 1 was confirmed to appear as a perception of solar power, and cluster 2 confirmed that words appeared because solar power is renewable and eco-friendly energy. Next, cluster 3 was confirmed to appear as a

perception of the government about solar power. And cluster 4 confirmed that words about companies and assumptions about solar power were clustered.

When emotional analysis was conducted, the year when there were many positive original data was confirmed as 2021, and the year when there were many negative original data was confirmed as 2016, and in 2021, the negative impact of households due to COVID-19 was identified as a movement to save electricity prices through solar power. It was also confirmed that positive opinions increased by reducing carbon emissions and policies on hydrogen energy as well as wind and power energy as the eco-friendly energy policy was implemented.

As a result, 75% of consumers' perceptions of solar energy at home are positive on average based on what was mentioned above, but as negative opinions still appear on average 25%, research on how to use it for waste control, installation, and maintenance should be conducted. Therefore, future studies will analyze the original data of negative opinions as big data and conduct basic research to collect policies on solar energy at home.

## **ACKNOWLEDGEMENT**

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