

LAMPIRAN

Tabel Data Kaggle

No.	Top (lux)	left (lux)	Middle (lux)	Bottom (lux)	Right (lux)	Current (A)	Time (s)	Voltage (V)	Power (W)	Panel Voltage (V)	Panel Power (W)	Power Efficiency (%)	Solar Efficiency (%)
1	581	581	628	679	549	0.46	7:00	2.5851	1.189146	18	8.28	14.36166667	0.58681786
2	580	580	628	679	549	0.51	7:15	2.59435	1.3231185	18	9.18	14.41305556	0.65060241
3	577	577	628	679	548	0.56	7:30	2.6036	1.458016	18	10.08	14.46444444	0.71438696
4	575	575	628	679	548	0.46	7:45	2.5851	1.189146	18	8.28	14.36166666	0.58681786
5	572	572	628	679	548	0.42	8:00	2.5777	1.082634	18	7.56	14.32055556	0.53579022
6	572	570	628	679	549	0.42	8:15	2.5777	1.082634	18	7.56	14.32055556	0.53579022
7	569	569	629	679	550	0.61	8:30	2.61285	1.5938385	18	10.98	14.51583333	0.77817151
8	567	567	629	679	549	0.56	8:45	2.6036	1.458016	18	10.08	14.46444444	0.71438696
9	565	565	628	680	548	0.61	9:00	2.61285	1.5938385	18	10.98	14.51583333	0.77817151
10	565	564	628	679	549	0.56	9:15	2.6036	1.458016	18	10.08	14.46444444	0.71438696
11	563	563	628	679	548	0.66	9:30	2.6221	1.730586	18	11.88	14.56722222	0.84195606
12	562	562	628	679	546	0.56	9:45	2.6036	1.458016	18	10.08	14.46444444	0.71438696
13	562	562	628	679	546	0.42	10:00	2.5777	1.082634	18	7.56	14.32055556	0.53579022
14	563	563	628	679	547	0.61	10:15	2.61285	1.5938385	18	10.98	14.51583333	0.77817151
15	563	563	628	679	547	0.37	10:30	2.56845	0.9503265	18	6.66	14.26916667	0.47200567
16	570	571	643	693	559	0.51	10:45	2.59435	1.3231185	18	9.18	14.41305556	0.65060241
17	563	563	629	679	548	0.61	11:00	2.61285	1.5938385	18	10.98	14.51583333	0.77817151
18	612	612	640	681	597	0.76	11:15	2.6406	2.006856	18	13.68	14.67	0.96952516
19	612	612	639	680	597	0.71	11:30	2.63135	1.8682585	18	12.78	14.61861111	0.90574061
20	622	622	650	692	608	0.66	11:45	2.6221	1.730586	18	11.88	14.56722222	0.84195606
21	612	612	639	680	598	0.71	12:00	2.63135	1.8682585	18	12.78	14.61861111	0.90574061
22	612	612	640	681	598	0.86	12:15	2.6591	2.286826	18	15.48	14.77277778	1.09709426
23	612	612	639	680	598	0.56	12:30	2.6036	1.458016	18	10.08	14.46444444	0.71438696
24	612	612	639	680	598	0.76	12:45	2.6406	2.006856	18	13.68	14.67	0.96952516
25	612	612	640	680	598	0.71	13:00	2.63135	1.8682585	18	12.78	14.61861111	0.90574061
26	612	612	639	680	598	0.81	13:15	2.64985	2.1463785	18	14.58	14.72138889	1.03330971
27	612	613	640	681	599	0.81	13:30	2.64985	2.1463785	18	14.58	14.72138889	1.03330971

No.	Top (lux)	left (lux)	Middle (lux)	Bottom (lux)	Right (lux)	Current (A)	Time (s)	Voltage (V)	Power (W)	Panel Voltage (V)	Panel Power (W)	Power Efficiency (%)	Solar Efficiency (%)
28	613	612	639	680	599	0.61	13:45	2.61285	1.5938385	18	10.98	14.51583333	0.77817151
29	612	612	639	680	598	0.76	14:00	2.6406	2.006856	18	13.68	14.67	0.96952516
30	612	612	639	680	599	0.66	14:15	2.6221	1.730586	18	11.88	14.56722222	0.84195606
31	614	612	640	680	599	0.61	14:30	2.61285	1.5938385	18	10.98	14.51583333	0.77817151
32	612	612	640	681	599	0.71	14:45	2.63135	1.8682585	18	12.78	14.61861111	0.90574061
33	615	612	639	680	599	0.81	15:00	2.64985	2.1463785	18	14.58	14.72138889	1.03330971
34	612	612	639	681	599	0.61	15:15	2.61285	1.5938385	18	10.98	14.51583333	0.77817151
35	612	612	640	680	599	0.66	15:30	2.6221	1.730586	18	11.88	14.56722222	0.84195606
36	626	626	654	696	613	0.66	15:45	2.6221	1.730586	18	11.88	14.56722222	0.84195606
37	613	612	640	681	599	0.61	16:00	2.61285	1.5938385	18	10.98	14.51583333	0.77817151
38	624	624	652	693	609	0.61	16:15	2.61285	1.5938385	18	10.98	14.51583333	0.77817151
39	612	612	640	680	598	0.66	16:30	2.6221	1.730586	18	11.88	14.56722222	0.84195606
40	613	613	640	681	598	0.71	16:45	2.63135	1.8682585	18	12.78	14.61861111	0.90574061
41	613	612	640	680	598	0.66	17:00	2.6221	1.730586	18	11.88	14.56722222	0.84195606
42	612	612	640	680	598	0.66	17:15	2.6221	1.730586	18	11.88	14.56722222	0.84195606
43	612	612	640	680	598	0.76	17:30	2.6406	2.006856	18	13.68	14.67	0.96952516
44	613	613	640	680	599	0.76	17:45	2.6406	2.006856	18	13.68	14.67	0.96952516
45	613	614	640	681	599	0.81	18:00	2.64985	2.1463785	18	14.58	14.72138889	1.03330971
46	613	612	640	680	600	0.81	18:15	2.64985	2.1463785	18	14.58	14.72138889	1.03330971
47	612	612	640	680	599	0.81	18:30	2.64985	2.1463785	18	14.58	14.72138889	1.03330971
48	612	612	640	680	599	0.86	18:45	2.6591	2.286826	18	15.48	14.77277778	1.09709426
49	612	612	640	680	599	0.86	19:00	2.6591	2.286826	18	15.48	14.77277778	1.09709426
50	612	612	640	680	599	0.81	19:15	2.64985	2.1463785	18	14.58	14.72138889	1.03330971
51	613	613	640	680	599	0.86	19:30	2.6591	2.286826	18	15.48	14.77277778	1.09709426
52	613	613	640	680	600	0.56	19:45	2.6036	1.458016	18	10.08	14.46444444	0.71438696
53	613	613	640	681	600	0.66	20:00	2.6221	1.730586	18	11.88	14.56722222	0.84195606
54	623	624	651	692	610	0.56	20:15	2.6036	1.458016	18	10.08	14.46444444	0.71438696
55	613	613	640	680	600	0.71	20:30	2.63135	1.8682585	18	12.78	14.61861111	0.90574061

No.	Top (lux)	left (lux)	Middle (lux)	Bottom (lux)	Right (lux)	Current (A)	Time (s)	Voltage (V)	Power (W)	Panel Voltage (V)	Panel Power (W)	Power Efficiency (%)	Solar Efficiency (%)
56	613	614	640	680	601	0.51	20:45	2.59435	1.323185	18	9.18	14.41305556	0.65060241
57	613	613	640	680	600	0.76	21:00	2.6406	2.006856	18	13.68	14.67	0.96952516
58	613	613	640	680	600	0.76	21:15	2.6406	2.006856	18	13.68	14.67	0.96952516
59	613	613	640	680	600	0.71	21:30	2.63135	1.8682585	18	12.78	14.61861111	0.90574061
60	613	613	640	680	601	0.66	21:45	2.6221	1.730586	18	11.88	14.56722222	0.84195606
61	613	613	640	681	601	0.71	22:00	2.63135	1.8682585	18	12.78	14.61861111	0.90574061
62	613	613	640	680	601	0.66	22:15	2.6221	1.730586	18	11.88	14.56722222	0.84195606
63	612	613	640	680	601	0.76	22:30	2.6406	2.006856	18	13.68	14.67	0.96952516
64	613	613	640	680	601	0.86	22:45	2.6591	2.286826	18	15.48	14.77277778	1.09709426
65	613	613	640	681	601	0.86	23:00	2.6591	2.286826	18	15.48	14.77277778	1.09709426
66	614	614	640	681	604	0.66	23:15	2.6221	1.730586	18	11.88	14.56722222	0.84195606
67	614	614	640	680	604	0.76	23:30	2.6406	2.006856	18	13.68	14.67	0.96952516
68	613	614	641	681	604	0.56	23:45	2.6036	1.458016	18	10.08	14.46444444	0.71438696
69	613	613	640	680	604	0.76	0:00	2.6406	2.006856	18	13.68	14.67	0.96952516
70	613	614	640	681	604	0.86	0:15	2.6591	2.286826	18	15.48	14.77277778	1.09709426
71	613	612	640	680	604	0.81	0:30	2.64985	2.1463785	18	14.58	14.72138889	1.03330971
72	621	621	653	694	616	0.56	0:45	2.6036	1.458016	18	10.08	14.46444444	0.71438696
73	621	621	655	696	618	0.71	1:00	2.63135	1.8682585	18	12.78	14.61861111	0.90574061
74	617	617	653	694	617	0.61	1:15	2.61285	1.5938385	18	10.98	14.51583333	0.77817151
75	614	614	652	692	616	0.76	1:30	2.6406	2.006856	18	13.68	14.67	0.96952516
76	602	602	640	680	605	0.9	1:45	2.6665	2.39985	18	16.2	14.81388889	1.1481219
77	600	600	640	681	605	0.86	2:00	2.6591	2.286826	18	15.48	14.77277778	1.09709426
78	597	597	640	680	605	0.76	2:15	2.6406	2.006856	18	13.68	14.67	0.96952516
79	595	595	640	680	606	0.95	2:30	2.67575	2.5419625	18	17.1	14.86527778	1.21190645
80	593	593	640	681	606	0.81	2:45	2.64985	2.1463785	18	14.58	14.72138889	1.03330971
81	590	589	639	680	607	0.81	3:00	2.64985	2.1463785	18	14.58	14.72138889	1.03330971
82	588	587	638	679	606	0.71	3:15	2.63135	1.8682585	18	12.78	14.61861111	0.90574061
83	585	584	638	678	605	0.81	3:30	2.64985	2.1463785	18	14.58	14.72138889	1.03330971

No.	Top (lux)	left (lux)	Middle (lux)	Bottom (lux)	Right (lux)	Current (A)	Time (s)	Voltage (V)	Power (W)	Panel Voltage (V)	Panel Power (W)	Power Efficiency (%)	Solar Efficiency (%)
84	582	582	637	677	605	0.71	3:45	2.63135	1.8682585	18	12.78	14.61861111	0.90574061
85	580	580	637	677	604	0.81	4:00	2.64985	2.1463785	18	14.58	14.72138889	1.03330971
86	577	577	636	677	604	0.76	4:15	2.6406	2.006856	18	13.68	14.67	0.96952516
87	575	575	636	677	603	0.81	4:30	2.64985	2.1463785	18	14.58	14.72138889	1.03330971
88	572	572	636	677	602	0.76	4:45	2.6406	2.006856	18	13.68	14.67	0.96952516
89	570	570	635	676	601	0.76	5:00	2.6406	2.006856	18	13.68	14.67	0.96952516
90	567	567	635	676	601	0.76	5:15	2.6406	2.006856	18	13.68	14.67	0.96952516
91	565	565	634	675	600	0.76	5:30	2.6406	2.006856	18	13.68	14.67	0.96952516
92	562	562	634	675	600	0.76	5:45	2.6406	2.006856	18	13.68	14.67	0.96952516
93	560	560	634	675	599	0.81	6:00	2.64985	2.1463785	18	14.58	14.72138889	1.03330971
94	557	557	633	674	598	0.81	6:15	2.64985	2.1463785	18	14.58	14.72138889	1.03330971
95	555	555	633	674	598	0.81	6:30	2.64985	2.1463785	18	14.58	14.72138889	1.03330971
96	552	552	632	674	597	0.76	6:45	2.6406	2.006856	18	13.68	14.67	0.96952516
97	550	550	632	673	597	0.81	7:00	2.64985	2.1463785	18	14.58	14.72138889	1.03330971
98	547	547	632	673	596	0.81	7:15	2.64985	2.1463785	18	14.58	14.72138889	1.03330971
99	545	545	631	672	595	0.76	7:30	2.6406	2.006856	18	13.68	14.67	0.96952516
100	542	542	631	672	595	0.76	7:45	2.6406	2.006856	18	13.68	14.67	0.96952516
101	540	540	630	672	594	0.76	8:00	2.6406	2.006856	18	13.68	14.67	0.96952516
102	537	537	630	671	593	0.76	8:15	2.6406	2.006856	18	13.68	14.67	0.96952516
103	535	535	630	671	593	0.76	8:30	2.6406	2.006856	18	13.68	14.67	0.96952516
104	532	532	629	670	592	0.76	8:45	2.6406	2.006856	18	13.68	14.67	0.96952516
105	530	530	629	670	592	0.76	9:00	2.6406	2.006856	18	13.68	14.67	0.96952516
106	527	527	629	670	591	0.76	9:15	2.6406	2.006856	18	13.68	14.67	0.96952516
107	525	525	628	669	590	0.76	9:30	2.6406	2.006856	18	13.68	14.67	0.96952516
108	522	522	628	669	590	0.76	9:45	2.6406	2.006856	18	13.68	14.67	0.96952516
109	520	520	628	669	589	0.76	10:00	2.6406	2.006856	18	13.68	14.67	0.96952516
110	517	517	627	668	588	0.76	10:15	2.6406	2.006856	18	13.68	14.67	0.96952516
111	515	515	627	668	588	0.76	10:30	2.6406	2.006856	18	13.68	14.67	0.96952516

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112	512	512	627	668	587	0.76	10:45	2.6406	2.006856	18	13.68	14.67	0.96952516
113	510	510	626	667	586	0.76	11:00	2.6406	2.006856	18	13.68	14.67	0.96952516
114	507	507	626	667	586	0.76	11:15	2.6406	2.006856	18	13.68	14.67	0.96952516
115	505	505	625	666	585	0.76	11:30	2.6406	2.006856	18	13.68	14.67	0.96952516
116	502	502	625	666	585	0.76	11:45	2.6406	2.006856	18	13.68	14.67	0.96952516
117	500	500	625	666	584	0.76	12:00	2.6406	2.006856	18	13.68	14.67	0.96952516
118	497	497	624	665	583	0.76	12:15	2.6406	2.006856	18	13.68	14.67	0.96952516
119	495	495	624	665	583	0.76	12:30	2.6406	2.006856	18	13.68	14.67	0.96952516
120	492	492	623	665	582	0.76	12:45	2.6406	2.006856	18	13.68	14.67	0.96952516
121	490	490	623	664	581	0.76	13:00	2.6406	2.006856	18	13.68	14.67	0.96952516
122	487	487	623	664	581	0.76	13:15	2.6406	2.006856	18	13.68	14.67	0.96952516
123	485	485	622	664	580	0.76	13:30	2.6406	2.006856	18	13.68	14.67	0.96952516
124	482	482	622	663	579	0.76	13:45	2.6406	2.006856	18	13.68	14.67	0.96952516
125	480	480	622	663	579	0.76	14:00	2.6406	2.006856	18	13.68	14.67	0.96952516
126	477	477	621	663	578	0.76	14:15	2.6406	2.006856	18	13.68	14.67	0.96952516
127	475	475	621	662	577	0.76	14:30	2.6406	2.006856	18	13.68	14.67	0.96952516
128	472	472	621	662	577	0.76	14:45	2.6406	2.006856	18	13.68	14.67	0.96952516
129	470	470	620	661	576	0.76	15:00	2.6406	2.006856	18	13.68	14.67	0.96952516
130	467	467	620	661	575	0.76	15:15	2.6406	2.006856	18	13.68	14.67	0.96952516
131	465	465	620	661	575	0.76	15:30	2.6406	2.006856	18	13.68	14.67	0.96952516
132	462	462	619	660	574	0.76	15:45	2.6406	2.006856	18	13.68	14.67	0.96952516
133	460	460	619	660	574	0.76	16:00	2.6406	2.006856	18	13.68	14.67	0.96952516
134	457	457	619	660	573	0.76	16:15	2.6406	2.006856	18	13.68	14.67	0.96952516
135	455	455	618	659	572	0.76	16:30	2.6406	2.006856	18	13.68	14.67	0.96952516

Gambar Pengolahan Data Menggunakan Python

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
from tabulate import tabulate
from sklearn.impute import SimpleImputer
from sklearn.cluster import KMeans
from sklearn.model_selection import train_test_split
from sklearn.metrics import silhouette_score
from sklearn.preprocessing import StandardScaler
from sklearn.decomposition import PCA

# 1. Load Data
df = pd.read_csv("data_kaggle.csv")

if 'timestamp' in df.columns:
    df['timestamp'] = pd.to_datetime(df['timestamp'], errors='coerce')
    df['time'] = df['timestamp'].dt.strftime('%H:%M')
    df = df.drop(columns=['timestamp'])

# 2. Hapus kolom yang tidak digunakan (jika ada)
if "Solar Efficiency" in df.columns:
    df = df.drop(columns=["Solar Efficiency"])
```

```
# --- Imputasi nilai NaN dengan rata-rata ---
# 3. Identifikasi kolom numerik untuk imputasi
# Sekarang 'left' dan 'bottom' seharusnya sudah bertipe numerik (float)
# dan akan disertakan oleh select_dtypes
numeric_cols = df.select_dtypes(include=np.number).columns.tolist()
# Hapus kolom yang tidak ingin diimputasi jika ada di numeric_cols
if 'time' in numeric_cols: # 'time' adalah string, jadi seharusnya tidak masuk sini
    numeric_cols.remove('time')
df_numeric = df[numeric_cols].copy() # Buat salinan untuk bekerja

# 4. Konversi semua kolom di df_numeric ke tipe numerik
for col in df_numeric.columns:
    df_numeric[col] = pd.to_numeric(df_numeric[col], errors='coerce')

# 5. Imputasi nilai yang hilang menggunakan SimpleImputer
imputer = SimpleImputer(strategy="mean")
X_raw = imputer.fit_transform(df_numeric)

# 6. Standarisasi seluruh data (bukan hanya train)
scaler = StandardScaler()
X_scaled = scaler.fit_transform(X_raw)
```

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# 7. Split data menjadi 60% training dan 40% testing
X_train, X_test = train_test_split(X_scaled, train_size=0.6, random_state=42)

# 8. KMeans clustering dengan k = 6
k_optimal = 6 # Sesuaikan ini berdasarkan hasil Elbow/Silhouette Anda
kmeans = KMeans(n_clusters=k_optimal, max_iter=500, random_state=10, n_init=10)
kmeans.fit(X_train)
train_labels = kmeans.labels_
test_labels = kmeans.predict(X_test)

# 9. Evaluasi Elbow & Silhouette
sse = []
silhouette_scores = []
K_range = range(2, 15)

for k in K_range:
    kmeans_k = KMeans(n_clusters=k, random_state=42, max_iter=500, n_init=10)
    cluster_labels_k = kmeans_k.fit_predict(X_scaled)
    sse.append(kmeans_k.inertia_)

    if len(np.unique(cluster_labels_k)) > 1 and X_scaled.shape[0] > k:
        silhouette_scores.append(silhouette_score(X_scaled, cluster_labels_k))
    else:
        silhouette_scores.append(np.nan)

# 10. Plot Elbow dan Silhouette
fig, axs = plt.subplots(1, 2, figsize=(14, 5))

axs[0].plot(K_range, sse, marker='o', linestyle='-', color='blue')
axs[0].set_title('Metode Elbow')
axs[0].set_xlabel('Jumlah Cluster (k)')
axs[0].set_ylabel('SSE (Sum of Squared Errors)')
axs[0].grid(True)

valid_silhouette_k = [K_range[i] for i, score in enumerate(silhouette_scores) if not np.isnan(score)]
valid_silhouette_scores = [score for score in silhouette_scores if not np.isnan(score)]

axs[1].plot(valid_silhouette_k, valid_silhouette_scores, marker='o', linestyle='-', color='green')
axs[1].set_title('Silhouette Score vs Jumlah Cluster')
axs[1].set_xlabel('Jumlah Cluster (k)')
axs[1].set_ylabel('Silhouette Score')
axs[1].grid(True)

plt.tight_layout()
plt.show()

```



```

▶ # 11. Tampilkan hasil centroid dalam bentuk tabel
cols = df_numeric.columns
centroids = scaler.inverse_transform(kmeans.cluster_centers_)
centroid_df = pd.DataFrame(centroids, columns=cols)
centroid_df['Cluster'] = centroid_df.index

print("=== Centroid Cluster ===")
print(tabulate(centroid_df.round(4), headers='keys', tablefmt='grid'))

# 12. Jumlah data per cluster
cluster_ids = range(k_optimal)
jumlah_train = [np.sum(train_labels == i) for i in cluster_ids]
jumlah_test = [np.sum(test_labels == i) for i in cluster_ids]

cluster_summary_df = pd.DataFrame({
    "Cluster": cluster_ids,
    "Jumlah Data (Train)": jumlah_train,
    "Jumlah Data (Test)": jumlah_test
})

print("\n=== Jumlah Data per Cluster ===")
print(tabulate(cluster_summary_df, headers="keys", tablefmt="grid"))

# 13. Grafik Garis: Perbandingan rata-rata tiap parameter antar cluster
plt.figure(figsize=(12, 7))
for i in range(len(centroid_df)):
    plt.plot(cols, centroid_df.loc[i, cols], marker='o', label=f'Cluster {i}')
plt.title("Perbandingan Nilai Rata-rata Tiap Parameter per Cluster")
plt.xlabel("Parameter")
plt.ylabel("Nilai")
plt.legend()
plt.grid(True)
plt.tight_layout()
plt.show()

```

```
# 14. PCA 2D Visualization
pca = PCA(n_components=2)
X_pca = pca.fit_transform(X_train)

plt.figure(figsize=(10, 7))
colors = plt.colormaps.get_cmap('tab10')

for cluster in cluster_ids:
    color_idx = cluster % colors.N
    plt.scatter(X_pca[train_labels == cluster, 0],
                X_pca[train_labels == cluster, 1],
                label=f'Cluster {cluster}',
                alpha=0.7,
                edgecolor='k',
                color=colors(color_idx))

plt.title("Visualisasi Clustering KMeans (PCA 2D)")
plt.xlabel("Komponen Utama 1")
plt.ylabel("Komponen Utama 2")
plt.legend()
plt.grid(True)
plt.tight_layout()
plt.show()
```

Gambar Pengolahan Data di laboratorium terpadu Teknik Elektro, Fakultas Teknik, Universitas Kristen Indonesia Toraja.



