

```
# Runtime > Change runtime type > GPU seç (varsa)
```

```
!pip -q install pandas numpy scikit-learn matplotlib tqdm
!pip -q install torch torchvision torchaudio
!pip -q install pyg_lib torch_scatter torch_sparse torch_cluster torch_spline_conv -f https://data.pyg.org/whl/torch-2.5.0+cu12
!pip -q install torch_geometric
```

```
2.5/2.5 MB 39.5 MB/s eta 0:00:00
10.9/10.9 MB 71.0 MB/s eta 0:00:00
5.1/5.1 MB 70.4 MB/s eta 0:00:00
3.4/3.4 MB 36.4 MB/s eta 0:00:00
994.8/994.8 kB 57.3 MB/s eta 0:00:00
63.7/63.7 kB 2.8 MB/s eta 0:00:00
1.3/1.3 MB 32.5 MB/s eta 0:00:00
```

```
import torch, torch_geometric
print("torch:", torch.__version__, "cuda:", torch.cuda.is_available(), "pyg:", torch_geometric.__version__)
```

```
/usr/local/lib/python3.12/dist-packages/torch_geometric/__init__.py:4: UserWarning: An issue occurred while importing 'pyg-lib'.
import torch_geometric.typing
/usr/local/lib/python3.12/dist-packages/torch_geometric/__init__.py:4: UserWarning: An issue occurred while importing 'torch-sca
import torch_geometric.typing
/usr/local/lib/python3.12/dist-packages/torch_geometric/__init__.py:4: UserWarning: An issue occurred while importing 'torch-clu
import torch_geometric.typing
/usr/local/lib/python3.12/dist-packages/torch_geometric/__init__.py:4: UserWarning: An issue occurred while importing 'torch-spl
import torch_geometric.typing
/usr/local/lib/python3.12/dist-packages/torch_geometric/__init__.py:4: UserWarning: An issue occurred while importing 'torch-spa
import torch_geometric.typing
torch: 2.9.0+cpu cuda: False pyg: 2.7.0
```

```
from google.colab import files
uploaded = files.upload() # "Derin Öğrenme ve Uygulamaları Veri Seti.xlsx" seç
```

Derin Öğre...Veri Seti.xlsx

Derin Öğrenme ve Uygulamaları Veri Seti.xlsx(application/vnd.openxmlformats-officedocument.spreadsheetml.sheet) - 239206 bytes, last modified: 12/18/2025 - 100% done

```
import pandas as pd
import numpy as np

# Veriyi tekrar oku (emin olmak için)
df = pd.read_excel(fname)

def extract_hour(x):
    if pd.isna(x):
        return np.nan
    if hasattr(x, "hour"): # datetime.time
        return x.hour
    try: # string veya int
        return int(str(x).split(":")[0])
    except:
        return np.nan

df["hour"] = df["Saat"].apply(extract_hour)



# Saat NaN olan satırları temizle (çok az olur, güvenli)
df = df.dropna(subset=["hour"]).reset_index(drop=True)

df["hour"] = df["hour"].astype(int)

# datetime oluştur
df["datetime"] = pd.to_datetime(df["Tarih"]) + pd.to_timedelta(df["hour"], unit="h")
df = df.sort_values("datetime").reset_index(drop=True)

print("Temizlenmiş veri boyutu:", df.shape)
df[["Tarih", "Saat", "hour", "datetime"]].head(10)
```

Temizlenmiş veri boyutu: (1464, 15)

	Tarih	Saat	hour	datetime	
0	2024-11-10	00:00:00	0	2024-11-10 00:00:00	
1	2024-11-10	06:00:00	6	2024-11-10 06:00:00	
2	2024-11-10	12:00:00	12	2024-11-10 12:00:00	
3	2024-11-10	18:00:00	18	2024-11-10 18:00:00	
4	2024-11-11	00:00:00	0	2024-11-11 00:00:00	
5	2024-11-11	06:00:00	6	2024-11-11 06:00:00	
6	2024-11-11	12:00:00	12	2024-11-11 12:00:00	
7	2024-11-11	18:00:00	18	2024-11-11 18:00:00	

```
cand = [c for c in df.columns if str(c).upper() in ["PTF","SMF"]]
print("Found targets:", cand)
```

Found targets: []

```
print(df.columns.tolist())
```

['Tarih', 'Saat', 'Hidroelektrik (HES)', 'Rüzgar (RES)', 'Güneş (GES)', 'Jeotermal (JES)', 'Biyokütle/Biyogaz', 'Doğalgaz', 'Köm

```
import re

# Kolon adlarını normalize et (boşluk, parantez, noktalama vs.)
norm_map = {}
for c in df.columns:
    cc = str(c).strip()
    cc_norm = re.sub(r"\s+", " ", cc) # çoklu boşlukları tek boşluk yap
    norm_map[c] = cc_norm

df = df.rename(columns=norm_map)

# İçerik araması: içinde PTF veya SMF geçen kolonları bul
cands = []
for c in df.columns:
    up = str(c).upper().replace("İ","I") # TR-EN farkına küçük önlem
    if "PTF" in up or "SMF" in up:
        cands.append(c)

print("Target candidates:", cands)
```

Target candidates: ['ptf_fiyat', 'smf_fiyat']

```
import pandas as pd
import numpy as np

TARGET_COL = "ptf_fiyat" # önce PTF

GEN_COLS = [
    'Hidroelektrik (HES)', 'Rüzgar (RES)', 'Güneş (GES)', 'Jeotermal (JES)',
    'Biyokütle/Biyogaz', 'Doğalgaz', 'Kömür', 'Sıvı Yakıt', 'Sıvılaştırılmış Gaz'
]

# numeric + temizle
df[GEN_COLS] = df[GEN_COLS].apply(pd.to_numeric, errors="coerce").fillna(0.0).clip(lower=0.0)
df[TARGET_COL] = pd.to_numeric(df[TARGET_COL], errors="coerce")

df = df.dropna(subset=[TARGET_COL]).reset_index(drop=True)

print("Rows:", len(df))
print("Target:", TARGET_COL, "min/max:", df[TARGET_COL].min(), df[TARGET_COL].max())
```

Rows: 1464
Target: ptf_fiyat min/max: 0.0 3400.0

```
df["dow"] = df["datetime"].dt.dayofweek
df["hour_sin"] = np.sin(2*np.pi*df["hour"]/24)
df["hour_cos"] = np.cos(2*np.pi*df["hour"]/24)
df["dow_sin"] = np.sin(2*np.pi*df["dow"]/7)
df["dow_cos"] = np.cos(2*np.pi*df["dow"]/7)
TIME_COLS = ["hour_sin", "hour_cos", "dow_sin", "dow_cos"]

split = int(len(df)*0.8)
train_df = df.iloc[:split].reset_index(drop=True)
test_df = df.iloc[split:].reset_index(drop=True)
print("train:", train_df.shape, "test:", test_df.shape)
```

train: (1171, 20) test: (293, 20)

```
from sklearn.linear_model import Ridge
from sklearn.metrics import mean_absolute_error, mean_squared_error, r2_score
import numpy as np
import matplotlib.pyplot as plt

Xtr = train_df[GEN_COLS + TIME_COLS].values
ytr = train_df[TARGET_COL].values

Xte = test_df[GEN_COLS + TIME_COLS].values
yte = test_df[TARGET_COL].values

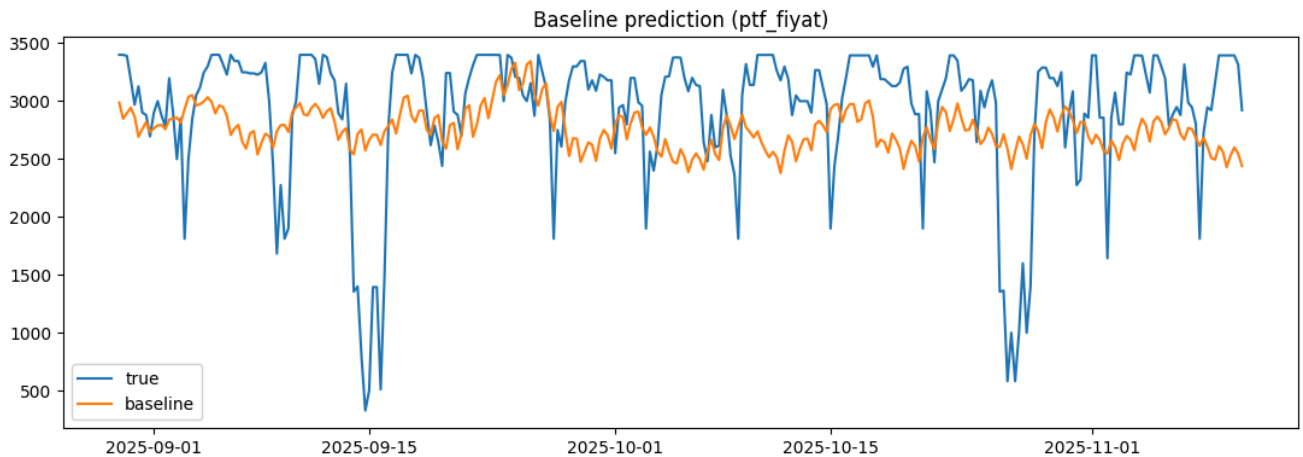
base = Ridge(alpha=1.0)
base.fit(Xtr, ytr)
pred_base = base.predict(Xte)

mse = mean_squared_error(yte, pred_base)
rmse = np.sqrt(mse)
mae = mean_absolute_error(yte, pred_base)
r2 = r2_score(yte, pred_base)

print("Baseline Ridge -> RMSE:", rmse, "| MAE:", mae, "| R2:", r2)

plt.figure(figsize=(11,4))
plt.plot(test_df["datetime"], yte, label="true")
plt.plot(test_df["datetime"], pred_base, label="baseline")
plt.title(f"Baseline prediction ({TARGET_COL})")
plt.legend(); plt.tight_layout(); plt.show()
```

Baseline Ridge -> RMSE: 613.6513261710746 | MAE: 481.57834107650115 | R2: -0.037603708131292324



```
import torch
from torch_geometric.data import Data

L = 24 # geçmiş pencere (istersen 48 yap)

num_nodes = len(GEN_COLS)
edges = [[i,j] for i in range(num_nodes) for j in range(num_nodes)]
edge_index = torch.tensor(edges, dtype=torch.long).t().contiguous()
```

```
def make_graph_samples(frame):
    data_list = []
    for t in range(L, len(frame)):
        hist = frame.iloc[t-L:t]

        x_list = []
        for c in GEN_COLS:
            seq = hist[c].values.astype(np.float32) # (L,)
            tf = hist[TIME_COLS].iloc[-1].values.astype(np.float32) # (4,)
            x_list.append(np.concatenate([seq, tf])) # (L+4,)

        x = torch.tensor(np.stack(x_list), dtype=torch.float32) # (nodes, L+4)
        y = torch.tensor([frame.iloc[t][TARGET_COL]], dtype=torch.float32) # (1,)
        data_list.append(Data(x=x, edge_index=edge_index, y=y))
    return data_list

train_ds = make_graph_samples(train_df)
test_ds = make_graph_samples(test_df)

print("train graphs:", len(train_ds), "test graphs:", len(test_ds))
```

train graphs: 1147 test graphs: 269

```
import torch.nn.functional as F
from torch_geometric.nn import GATConv, global_mean_pool
from torch_geometric.loader import DataLoader
from sklearn.metrics import mean_absolute_error, mean_squared_error, r2_score
import numpy as np
import matplotlib.pyplot as plt

device = torch.device("cuda" if torch.cuda.is_available() else "cpu")
print("device:", device)

train_loader = DataLoader(train_ds, batch_size=64, shuffle=True)
test_loader = DataLoader(test_ds, batch_size=64, shuffle=False)

class GATPrice(torch.nn.Module):
    def __init__(self, in_dim, hid=64, heads=4):
        super().__init__()
        self.gat1 = GATConv(in_dim, hid, heads=heads, dropout=0.2)
        self.gat2 = GATConv(hid*heads, hid, heads=1, dropout=0.2)
        self.lin = torch.nn.Linear(hid, 1)

    def forward(self, data):
        x, edge_index, batch = data.x, data.edge_index, data.batch
        x = F.elu(self.gat1(x, edge_index))
        x = F.elu(self.gat2(x, edge_index))
        g = global_mean_pool(x, batch)
        return self.lin(g).squeeze(-1)

model = GATPrice(in_dim=L+4).to(device)
opt = torch.optim.Adam(model.parameters(), lr=1e-3, weight_decay=1e-4)

def run_eval(loader):
    model.eval()
    ys, ps = [], []
    with torch.no_grad():
        for data in loader:
            data = data.to(device)
            p = model(data)
            ys.append(data.y.squeeze(-1).detach().cpu().numpy())
            ps.append(p.detach().cpu().numpy())
    return np.concatenate(ys), np.concatenate(ps)

EPOCHS = 20
for ep in range(1, EPOCHS+1):
    model.train()
    total = 0.0
    for data in train_loader:
        data = data.to(device)
        opt.zero_grad()
        p = model(data)
        loss = F.mse_loss(p, data.y.squeeze(-1))
        loss.backward()
        opt.step()
    total += loss.item()
```

```

if ep % 5 == 0 or ep == 1:
    y, p = run_eval(test_loader)
    mse = mean_squared_error(y, p)
    rmse = np.sqrt(mse)
    mae = mean_absolute_error(y, p)
    r2 = r2_score(y, p)
    print(f"Epoch {ep:02d} | train_loss {total/len(train_loader):.4f} | RMSE {rmse:.2f} MAE {mae:.2f} R2 {r2:.3f}")

# Final plot
y, p = run_eval(test_loader)

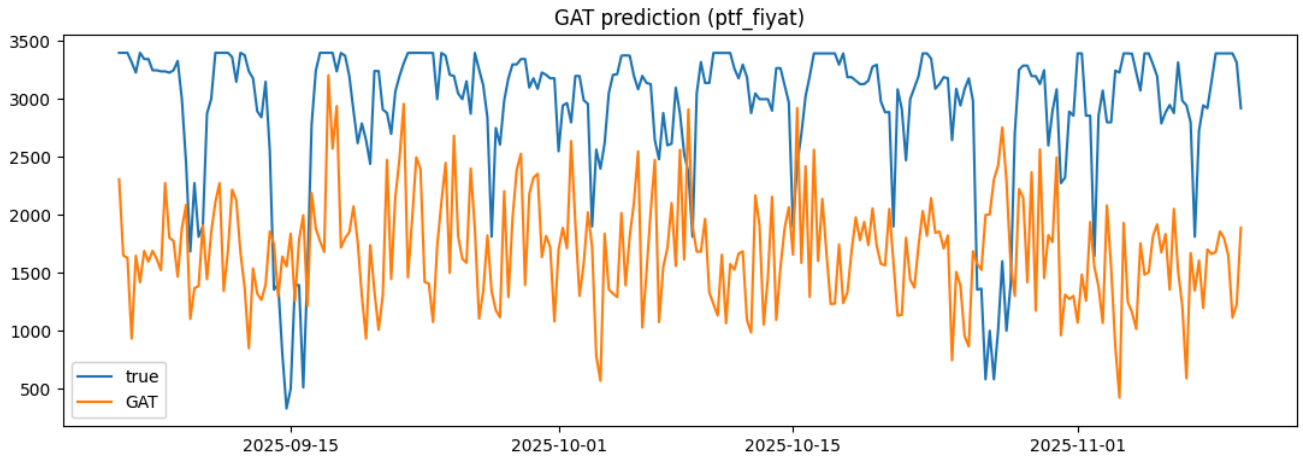
plt.figure(figsize=(11,4))
plt.plot(test_df["datetime"].iloc[L:], y, label="true")
plt.plot(test_df["datetime"].iloc[L:], p, label="GAT")
plt.title(f"GAT prediction ({TARGET_COL})")
plt.legend(); plt.tight_layout(); plt.show()

```

```

device: cpu
Epoch 01 | train_loss 12832777.5694 | RMSE 1049.45 MAE 870.10 R2 -1.863
Epoch 05 | train_loss 2957857.0000 | RMSE 813.33 MAE 707.52 R2 -0.720
Epoch 10 | train_loss 2911617.0833 | RMSE 812.02 MAE 677.25 R2 -0.714
Epoch 15 | train_loss 2617964.6181 | RMSE 686.24 MAE 578.08 R2 -0.224
Epoch 20 | train_loss 1576894.8333 | RMSE 1459.45 MAE 1344.78 R2 -4.537

```



Normalizasyon

```

from sklearn.preprocessing import StandardScaler
import numpy as np

# 1) önceki fiyat (lag)
df["prev_price"] = df[TARGET_COL].shift(1)
df = df.dropna(subset=["prev_price"]).reset_index(drop=True)

# time split'i yeniden kur (shift yüzünden 1 satır gitti)
split = int(len(df)*0.8)
train_df = df.iloc[:split].reset_index(drop=True)
test_df = df.iloc[split:].reset_index(drop=True)

# 2) scaler: sadece train ile fit (doğru yöntem)
x_scaler = StandardScaler()
y_scaler = StandardScaler()

train_X_raw = train_df[GEN_COLS + TIME_COLS + ["prev_price"]].values
test_X_raw = test_df[GEN_COLS + TIME_COLS + ["prev_price"]].values

train_y_raw = train_df[[TARGET_COL]].values
test_y_raw = test_df[[TARGET_COL]].values

x_scaler.fit(train_X_raw)
y_scaler.fit(train_y_raw)

train_X = x_scaler.transform(train_X_raw)
test_X = x_scaler.transform(test_X_raw)

```

```
train_y = y_scaler.transform(train_y_raw).reshape(-1)
test_y = y_scaler.transform(test_y_raw).reshape(-1)

print("OK: normalized + prev_price ready")
```

OK: normalized + prev_price ready

```
import torch
from torch_geometric.data import Data

L = 24 # pencere

num_nodes = len(GEN_COLS)
edges = [[i,j] for i in range(num_nodes) for j in range(num_nodes)]
edge_index = torch.tensor(edges, dtype=torch.long).t().contiguous()

def make_graph_samples_from_scaled(frame_X, frame_y, frame_dt):
    data_list = []
    for t in range(L, len(frame_y)):
        # geçmiş pencere [t-L, ..., t-1]
        hist_X = frame_X[t-L:t] # (L, feat_total)

        # hist_X içinde kolon sırası: GEN_COLS + TIME_COLS + prev_price
        # Biz node başına: [L üretim seq] + [time(4)] + [prev_price(1)]
        # time ve prev_price: t-1 satırından alıyoruz (son saat)
        last = hist_X[-1]
        time_feat = last[len(GEN_COLS):len(GEN_COLS)+len(TIME_COLS)] # (4,)
        prev_p = last[len(GEN_COLS)+len(TIME_COLS):len(GEN_COLS)+len(TIME_COLS)+1] # (1,)

        x_list = []
        for i, c in enumerate(GEN_COLS):
            seq = hist_X[:, i].astype(np.float32) # (L,) sadece o kaynağın geçmişi
            feat = np.concatenate([seq, time_feat.astype(np.float32), prev_p.astype(np.float32)]) # (L+4+1,)
            x_list.append(feat)

        x = torch.tensor(np.stack(x_list), dtype=torch.float32) # (nodes, L+5)
        y = torch.tensor([frame_y[t]], dtype=torch.float32) # scaled target
        data_list.append(Data(x=x, edge_index=edge_index, y=y))
    return data_list

train_dt = train_df["datetime"].values
test_dt = test_df["datetime"].values

train_ds = make_graph_samples_from_scaled(train_X, train_y, train_dt)
test_ds = make_graph_samples_from_scaled(test_X, test_y, test_dt)

print("train graphs:", len(train_ds), "test graphs:", len(test_ds))
```

train graphs: 1146 test graphs: 269

```
import torch
import torch.nn.functional as F
from torch_geometric.nn import GATConv, global_mean_pool
from torch_geometric.loader import DataLoader
from sklearn.metrics import mean_absolute_error, mean_squared_error, r2_score
import numpy as np
import matplotlib.pyplot as plt

device = torch.device("cuda" if torch.cuda.is_available() else "cpu")

train_loader = DataLoader(train_ds, batch_size=64, shuffle=True)
test_loader = DataLoader(test_ds, batch_size=64, shuffle=False)

class GATPrice(torch.nn.Module):
    def __init__(self, in_dim, hid=64, heads=4):
        super().__init__()
        self.gat1 = GATConv(in_dim, hid, heads=heads, dropout=0.2)
        self.gat2 = GATConv(hid*heads, hid, heads=1, dropout=0.2)
        self.lin = torch.nn.Linear(hid, 1)

    def forward(self, data):
        x, edge_index, batch = data.x, data.edge_index, data.batch
        x = F.relu(self.gat1(x, edge_index))
        x = F.relu(self.gat2(x, edge_index))
```

```

        g = global_mean_pool(x, batch)
        return self.lin(g).squeeze(-1)

model = GATPrice(in_dim=L+5).to(device)
opt = torch.optim.Adam(model.parameters(), lr=1e-3, weight_decay=1e-4)

def run_eval(loader):
    model.eval()
    ys, ps = [], []
    with torch.no_grad():
        for data in loader:
            data = data.to(device)
            p = model(data)
            ys.append(data.y.squeeze(-1).detach().cpu().numpy())
            ps.append(p.detach().cpu().numpy())
    return np.concatenate(ys), np.concatenate(ps)

EPOCHS = 25
for ep in range(1, EPOCHS+1):
    model.train()
    total = 0.0
    for data in train_loader:
        data = data.to(device)
        opt.zero_grad()
        p = model(data)
        loss = F.mse_loss(p, data.y.squeeze(-1))
        loss.backward()
        opt.step()
        total += loss.item()

    if ep % 5 == 0 or ep == 1:
        y_s, p_s = run_eval(test_loader)
        # scaled -> gerçek fiyat
        y_real = y_scaler.inverse_transform(y_s.reshape(-1,1)).reshape(-1)
        p_real = y_scaler.inverse_transform(p_s.reshape(-1,1)).reshape(-1)

        mse = mean_squared_error(y_real, p_real)
        rmse = np.sqrt(mse)
        mae = mean_absolute_error(y_real, p_real)
        r2 = r2_score(y_real, p_real)
        print(f"Epoch {ep:02d} | train_loss {total/len(train_loader):.4f} | RMSE {rmse:.2f} MAE {mae:.2f} R2 {r2:.3f}")

# final plot
y_s, p_s = run_eval(test_loader)
y_real = y_scaler.inverse_transform(y_s.reshape(-1,1)).reshape(-1)
p_real = y_scaler.inverse_transform(p_s.reshape(-1,1)).reshape(-1)

plt.figure(figsize=(11,4))
plt.plot(test_df["datetime"].iloc[L:], y_real, label="true")
plt.plot(test_df["datetime"].iloc[L:], p_real, label="GAT (norm+prev)")
plt.title(f"GAT prediction ({TARGET_COL}) - normalized + prev_price")
plt.legend(); plt.tight_layout(); plt.show()

```

```
Epoch 01 | train_loss 0.6601 | RMSE 488.13 MAE 339.84 R2 0.381
Epoch 05 | train_loss 0.5087 | RMSE 459.64 MAE 321.07 R2 0.451
Epoch 10 | train_loss 0.4570 | RMSE 449.93 MAE 324.88 R2 0.474
Epoch 15 | train_loss 0.4395 | RMSE 455.27 MAE 343.04 R2 0.461
```

```
import numpy as np
import pandas as pd
import torch
from torch_geometric.loader import DataLoader

num_nodes = len(GEN_COLS)

# test graph'ları tek tek gez
test_loader_1 = DataLoader(test_ds, batch_size=1, shuffle=False)

out_sum = np.zeros(num_nodes, dtype=np.float64)
out_cnt = np.zeros(num_nodes, dtype=np.float64)
in_sum = np.zeros(num_nodes, dtype=np.float64)
in_cnt = np.zeros(num_nodes, dtype=np.float64)

model.eval()
with torch.no_grad():
    for data in test_loader_1:
        data = data.to(device)

        # 1. katman attention
        _, (eid_idx, alpha) = model.gat1(data.x, data.edge_index, return_attention_weights=True)

        if alpha.dim() == 2:
            a = alpha.mean(dim=1).detach().cpu().numpy() # (E,)
        else:
            a = alpha.view(-1).detach().cpu().numpy()

        src = eid_idx[0].detach().cpu().numpy()
        dst = eid_idx[1].detach().cpu().numpy()

        # batch_size=1 olduğundan src/dst kesin 0..num_nodes-1 aralığında
        np.add.at(out_sum, src, a); np.add.at(out_cnt, src, 1)
        np.add.at(in_sum, dst, a); np.add.at(in_cnt, dst, 1)

out_mean = out_sum / np.maximum(out_cnt, 1)
in_mean = in_sum / np.maximum(in_cnt, 1)

att_df = pd.DataFrame({
    "node": GEN_COLS,
    "outgoing_att_mean": out_mean,
    "incoming_att_mean": in_mean
}).sort_values("outgoing_att_mean", ascending=False)

display(att_df)

# RES & GES net skorlar
res_out = float(att_df.loc[att_df["node"]=="Rüzgar (RES)", "outgoing_att_mean"].values[0])
res_in = float(att_df.loc[att_df["node"]=="Rüzgar (RES)", "incoming_att_mean"].values[0])
ges_out = float(att_df.loc[att_df["node"]=="Güneş (GES)", "outgoing_att_mean"].values[0])
ges_in = float(att_df.loc[att_df["node"]=="Güneş (GES)", "incoming_att_mean"].values[0])

print("\nRES attention -> outgoing:", res_out, "| incoming:", res_in)
print("GES attention -> outgoing:", ges_out, "| incoming:", ges_in)
```

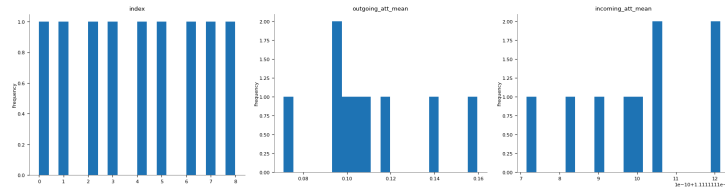

1 to 9 of 9 entries

index	node	outgoing_att_mean	incoming_att_mean
4	Biyokütle/Biyogaz	0.15961574961557118	0.1111111112142067
1	Rüzgar (RES)	0.14151024685934868	0.11111111105340835
2	Güneş (GES)	0.11967878718004524	0.11111111104879212
0	Hidroelektrik (HES)	0.11064523433014682	0.111111111071565485
5	Doğalgaz	0.10392065435834152	0.111111111090607396
6	Kömür	0.10193545958554262	0.11111111119497245
7	Sıvı Yakıt	0.09739232165004191	0.111111111097647133
8	Sıvılaştırılmış Gaz	0.0941949740124544	0.111111111083413786
3	Jeotermal (JES)	0.07110657134716149	0.111111111099493622

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RES attention -> outgoing: 0.14151024685934868 | incoming: 0.11111111105340835

GES attention -> outgoing: 0.11967878718004524 | incoming: 0.11111111104879212

Distributions**2-d distributions**

```

import numpy as np
import matplotlib.pyplot as plt
from torch_geometric.loader import DataLoader

num_nodes = len(GEN_COLS)
node2idx = {n:i for i,n in enumerate(GEN_COLS)}
idx_RES = node2idx["Rüzgar (RES)"]
idx_GES = node2idx["Güneş (GES)"]

# Batch offset problemi olmasın diye batch_size=1
test_loader_1 = DataLoader(test_ds, batch_size=1, shuffle=False)

# RES -> dst attention biriktir
res_to_sum = np.zeros(num_nodes, dtype=np.float64)
res_to_cnt = np.zeros(num_nodes, dtype=np.float64)

# GES -> dst attention biriktir
ges_to_sum = np.zeros(num_nodes, dtype=np.float64)
ges_to_cnt = np.zeros(num_nodes, dtype=np.float64)

model.eval()
with torch.no_grad():
    for data in test_loader_1:
        data = data.to(device)

        # 1. katman attention
        _, (eid_idx, alpha) = model.gat1(data.x, data.edge_index, return_attention_weights=True)

        # alpha: (E, heads) -> head ortalaması
        if alpha.dim() == 2:
            a = alpha.mean(dim=1).detach().cpu().numpy()
        else:
            a = alpha.view(-1).detach().cpu().numpy()

        src = eid_idx[0].detach().cpu().numpy()
        dst = eid_idx[1].detach().cpu().numpy()

        # RES kaynaklı edge'ler
        mask_res = (src == idx_RES)
        np.add.at(res_to_sum, dst[mask_res], a[mask_res])
        np.add.at(res_to_cnt, dst[mask_res], 1)

        # GES kaynaklı edge'ler
        mask_ges = (src == idx_GES)
        np.add.at(ges_to_sum, dst[mask_ges], a[mask_ges])
        np.add.at(ges_to_cnt, dst[mask_ges], 1)

```

```
np.add.at(ges_to_cnt, dst[mask_ges], 1)

# Ortalama attention (RES->dst, GES->dst)
res_to_mean = res_to_sum / np.maximum(res_to_cnt, 1)
ges_to_mean = ges_to_sum / np.maximum(ges_to_cnt, 1)

# Self-loop'u istersen çıkar (yorumlaması daha temiz olur)
# res_to_mean[idx_RES] = 0
# ges_to_mean[idx_GES] = 0

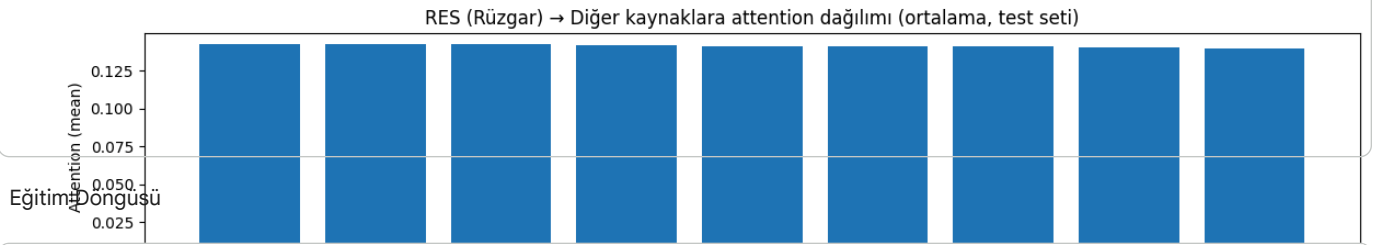
# Sıralama: en çok attention alan hedefler
order_res = np.argsort(res_to_mean)[::-1]
order_ges = np.argsort(ges_to_mean)[::-1]

# ---- Plot: RES dağılımı
plt.figure(figsize=(12,4))
plt.bar([GEN_COLS[i] for i in order_res], res_to_mean[order_res])
plt.xticks(rotation=75, ha="right")
plt.title("RES (Rüzgar) → Diğer kaynaklara attention dağılımı (ortalama, test seti)")
plt.ylabel("Attention (mean)")
plt.tight_layout()
plt.show()

# ---- Plot: GES dağılımı
plt.figure(figsize=(12,4))
plt.bar([GEN_COLS[i] for i in order_ges], ges_to_mean[order_ges])
plt.xticks(rotation=75, ha="right")
plt.title("GES (Güneş) → Diğer kaynaklara attention dağılımı (ortalama, test seti)")
plt.ylabel("Attention (mean)")
plt.tight_layout()
plt.show()

# İstersen top-5 hedefleri yazdır
top5_res = [(GEN_COLS[i], float(res_to_mean[i])) for i in order_res[:5]]
top5_ges = [(GEN_COLS[i], float(ges_to_mean[i])) for i in order_ges[:5]]

print("Top-5 RES ->", top5_res)
print("Top-5 GES ->", top5_ges)
```



```
import os
```

```
os.makedirs("results/figures", exist_ok=True)
print("results/figures hazır")
```

```
results/figures hazır
```



```
train_loss_hist = []
rmse_hist = []
mae_hist = []
r2_hist = []

EPOCHS = 25

for ep in range(1, EPOCHS+1):
    model.train()
    epoch_loss = 0.0

    for data in train_loader:
        data = data.to(device)
        opt.zero_grad()
        p = model(data)
        loss = F.mse_loss(p, data.y.squeeze(-1))
        loss.backward()
        opt.step()
        epoch_loss += loss.item()

    epoch_loss /= len(train_loader)
    train_loss_hist.append(epoch_loss)

    # ---- test evaluation ----
    y_s, p_s = run_eval(test_loader)

    # scaled -> gerçek
    y_real = y_scaler.inverse_transform(y_s.reshape(-1,1)).reshape(-1)
    p_real = y_scaler.inverse_transform(p_s.reshape(-1,1)).reshape(-1)

    mse = mean_squared_error(y_real, p_real)
    rmse = np.sqrt(mse)
    mae = mean_absolute_error(y_real, p_real)
    r2 = r2_score(y_real, p_real)

    rmse_hist.append(rmse)
    mae_hist.append(mae)
    r2_hist.append(r2)

    print(f"Epoch {ep:02d} | loss {epoch_loss:.4f} | RMSE {rmse:.2f} | MAE {mae:.2f} | R2 {r2:.3f}")
```

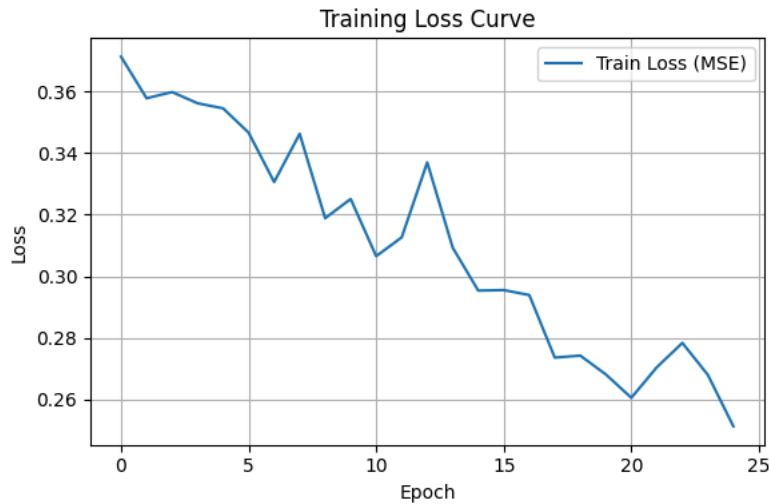
Epoch 01	loss 0.3712	RMSE 483.30	MAE 359.60	R2 0.393
Epoch 02	loss 0.3577	RMSE 476.49	MAE 351.01	R2 0.410
Epoch 03	loss 0.3597	RMSE 476.66	MAE 338.54	R2 0.409
Epoch 04	loss 0.3561	RMSE 472.09	MAE 341.14	R2 0.421
Epoch 05	loss 0.3544	RMSE 486.87	MAE 361.17	R2 0.384
Epoch 06	loss 0.3466	RMSE 472.25	MAE 335.38	R2 0.420
Epoch 07	loss 0.3306	RMSE 495.86	MAE 366.49	R2 0.361
Epoch 08	loss 0.3462	RMSE 476.83	MAE 353.58	R2 0.409
Epoch 09	loss 0.3188	RMSE 493.82	MAE 358.58	R2 0.366
Epoch 10	loss 0.3251	RMSE 471.39	MAE 330.46	R2 0.422
Epoch 11	loss 0.3065	RMSE 484.67	MAE 360.48	R2 0.389
Epoch 12	loss 0.3126	RMSE 518.86	MAE 390.52	R2 0.300
Epoch 13	loss 0.3369	RMSE 467.87	MAE 335.42	R2 0.431
Epoch 14	loss 0.3093	RMSE 484.45	MAE 346.59	R2 0.390

Epoch 15	loss 0.2954	RMSE 500.15	MAE 373.20	R2 0.350
Epoch 16	loss 0.2955	RMSE 505.85	MAE 382.60	R2 0.335
Epoch 17	loss 0.2939	RMSE 507.43	MAE 383.28	R2 0.331
Epoch 18	loss 0.2736	RMSE 503.67	MAE 375.42	R2 0.341
Epoch 19	loss 0.2743	RMSE 502.36	MAE 385.48	R2 0.344
Epoch 20	loss 0.2682	RMSE 513.26	MAE 393.82	R2 0.315
Epoch 21	loss 0.2606	RMSE 525.00	MAE 402.29	R2 0.284
Epoch 22	loss 0.2705	RMSE 518.29	MAE 390.14	R2 0.302
Epoch 23	loss 0.2784	RMSE 519.86	MAE 406.49	R2 0.297
Epoch 24	loss 0.2680	RMSE 572.06	MAE 449.15	R2 0.149
Epoch 25	loss 0.2514	RMSE 511.94	MAE 386.65	R2 0.319

Loss Curve

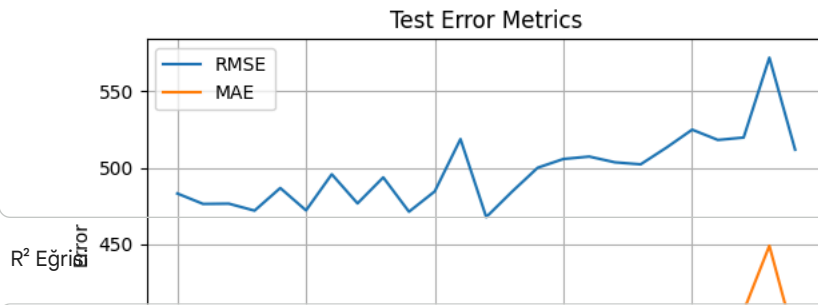
```
import matplotlib.pyplot as plt

plt.figure(figsize=(6,4))
plt.plot(train_loss_hist, label="Train Loss (MSE)")
plt.xlabel("Epoch")
plt.ylabel("Loss")
plt.title("Training Loss Curve")
plt.legend()
plt.grid(True)
plt.tight_layout()
plt.savefig("results/figures/loss_curve.png", dpi=150)
plt.show()
```

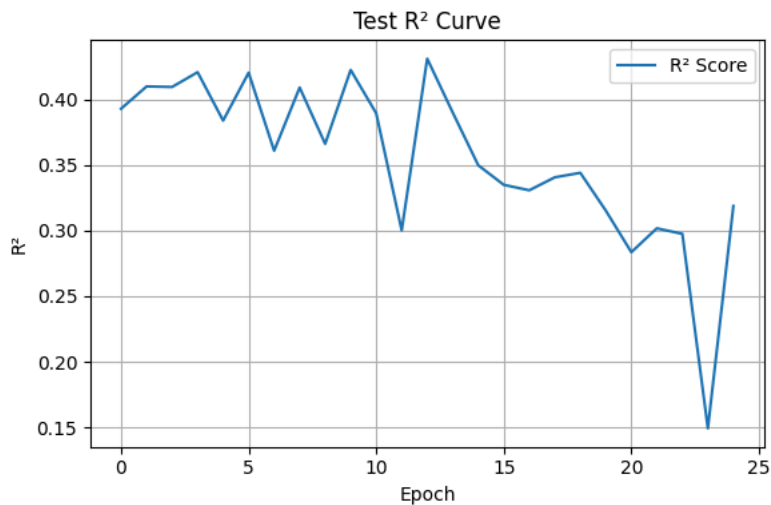


RMSE / MAE Eğrileri

```
plt.figure(figsize=(6,4))
plt.plot(rmse_hist, label="RMSE")
plt.plot(mae_hist, label="MAE")
plt.xlabel("Epoch")
plt.ylabel("Error")
plt.title("Test Error Metrics")
plt.legend()
plt.grid(True)
plt.tight_layout()
plt.savefig("results/figures/error_metrics_curve.png", dpi=150)
plt.show()
```



```
plt.figure(figsize=(6,4))
plt.plot(r2_hist, label="R² Score")
plt.xlabel("Epoch")
plt.ylabel("R²")
plt.title("Test R² Curve")
plt.legend()
plt.grid(True)
plt.tight_layout()
plt.savefig("results/figures/r2_curve.png", dpi=150)
plt.show()
```



JSON olarak kaydı

```
import json

metrics = {
    "final_rmse": rmse_hist[-1],
    "final_mae": mae_hist[-1],
    "final_r2": r2_hist[-1],
    "rmse_per_epoch": rmse_hist,
    "mae_per_epoch": mae_hist,
    "r2_per_epoch": r2_hist
}

with open("results/metrics.json", "w") as f:
    json.dump(metrics, f, indent=2)

print("metrics.json kaydedildi")
```

metrics.json kaydedildi

GiTHUB Bağlantısı

