

# **Sürdürülebilir Doğal Gaz, Yakıt Piyasa Eşleşmeleri Ve Türkiye'ye etkileri**

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# Yasal Uyarı

- Bu sunumdaki görüş/öneri/çalışma ve düşünceler hiçbir kurum, kuruluş veya derneğe atfedilemezler.

# İçerik

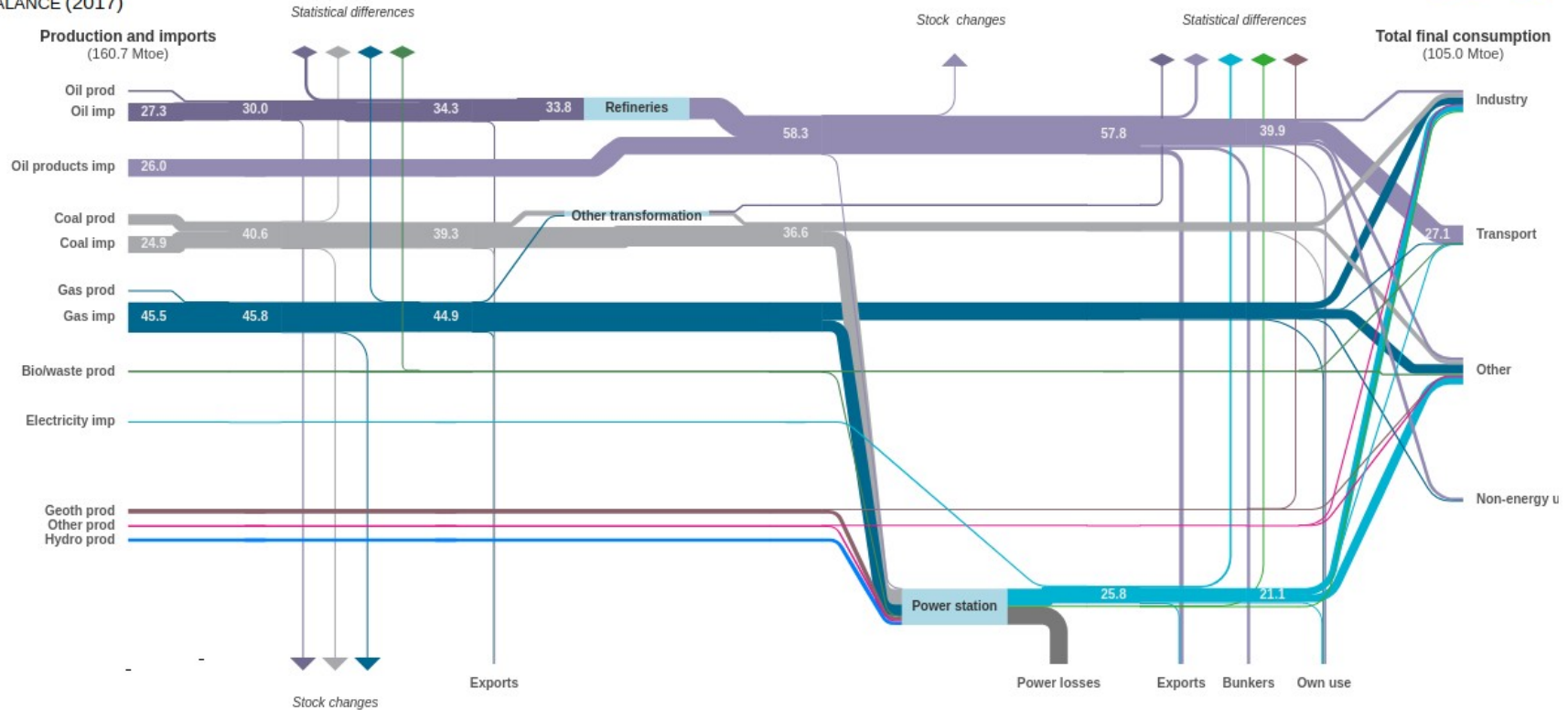
- Kanuni altyapı
- Türkiye enerji dengesi
- Doğalgaz arz/talep
- Yenilenebilir etkisi
- Diğer piyasalara etkisi



# Türkiye – Enerji Dengesi

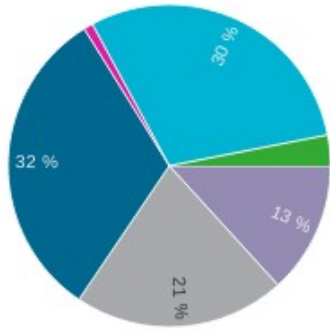
Turkey  
BALANCE (2017)

Millions of tonnes of oil equivalent



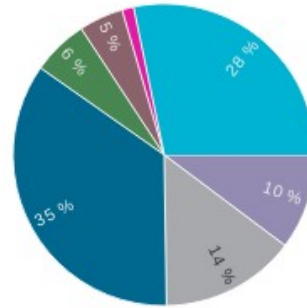
# Nihai Tüketimlerde

Industry (2017)  
Total: 32.5 Mtoe



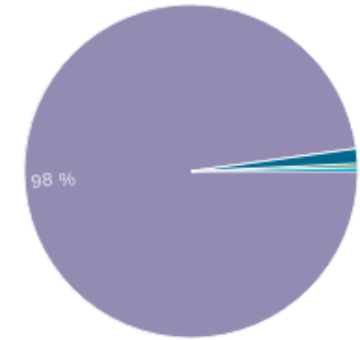
Oil	0.0 Mtoe
Oil products	4.3 Mtoe
Coal	6.9 Mtoe
Natural gas	10.3 Mtoe
Solar/tide/wind	0.3 Mtoe
Electricity	9.7 Mtoe
Heat	1.0 Mtoe

Other (2017)  
Total: 40.0 Mtoe



Oil	0.0 Mtoe
Oil products	4.1 Mtoe
Coal	5.8 Mtoe
Natural gas	14.0 Mtoe
Biofuels and waste	2.4 Mtoe
Geothermal	1.9 Mtoe
Solar/tide/wind	0.5 Mtoe
Electricity	11.3 Mtoe

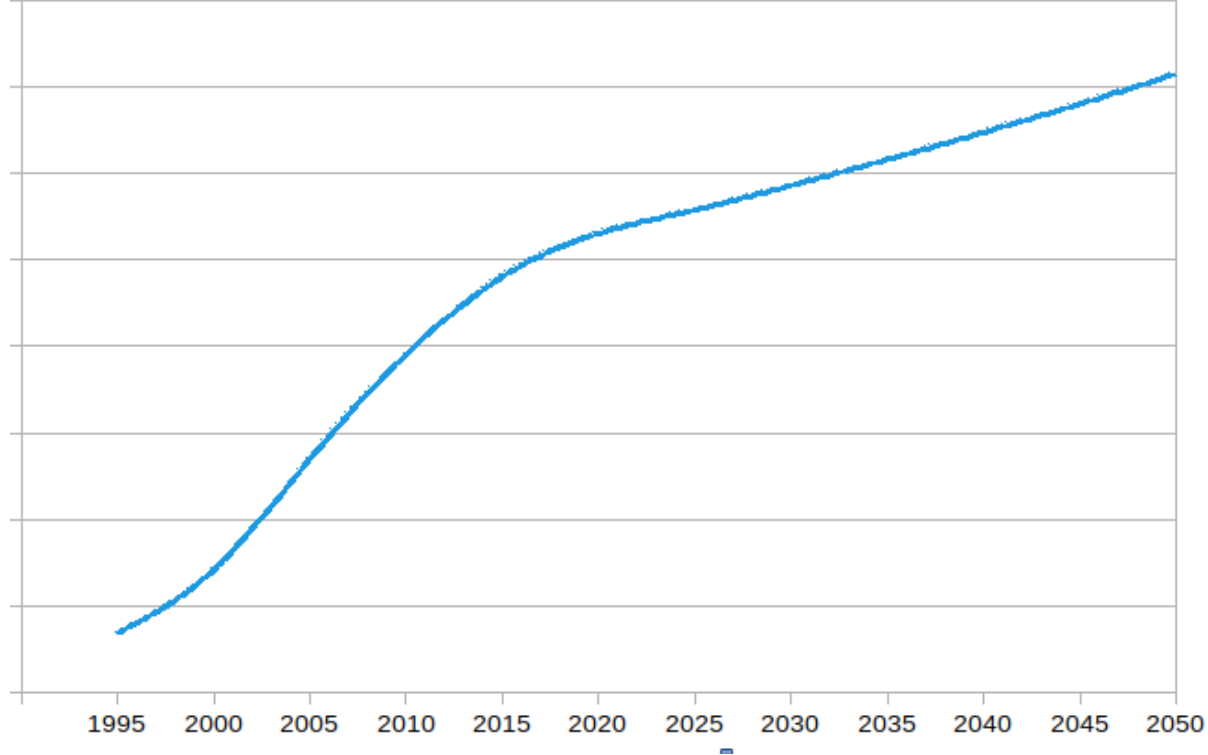
Transport (2017)  
Total: 27.7 Mtoe



Oil	0.0 Mtoe
Oil products	27.1 Mtoe
Coal	0.0 Mtoe
Natural gas	0.4 Mtoe
Biofuels and waste	0.1 Mtoe
Electricity	0.1 Mtoe

# Talep tahminleri var

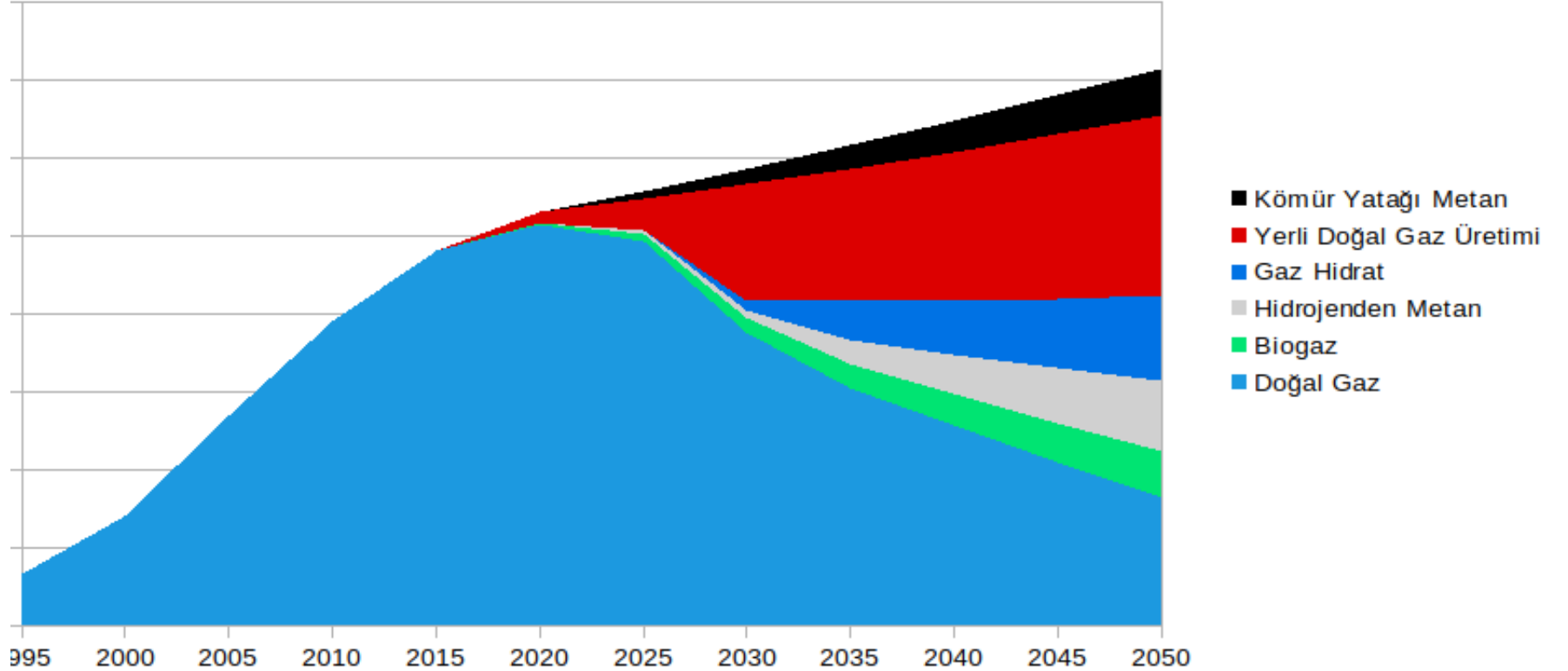
Doğal Gaz Talebi - Tahmini Gelişim



UYARI: İçerik gerçek hesaplara dayanmayıp, tartışma amaçlıdır

# Ama bir çok arz tahmini var

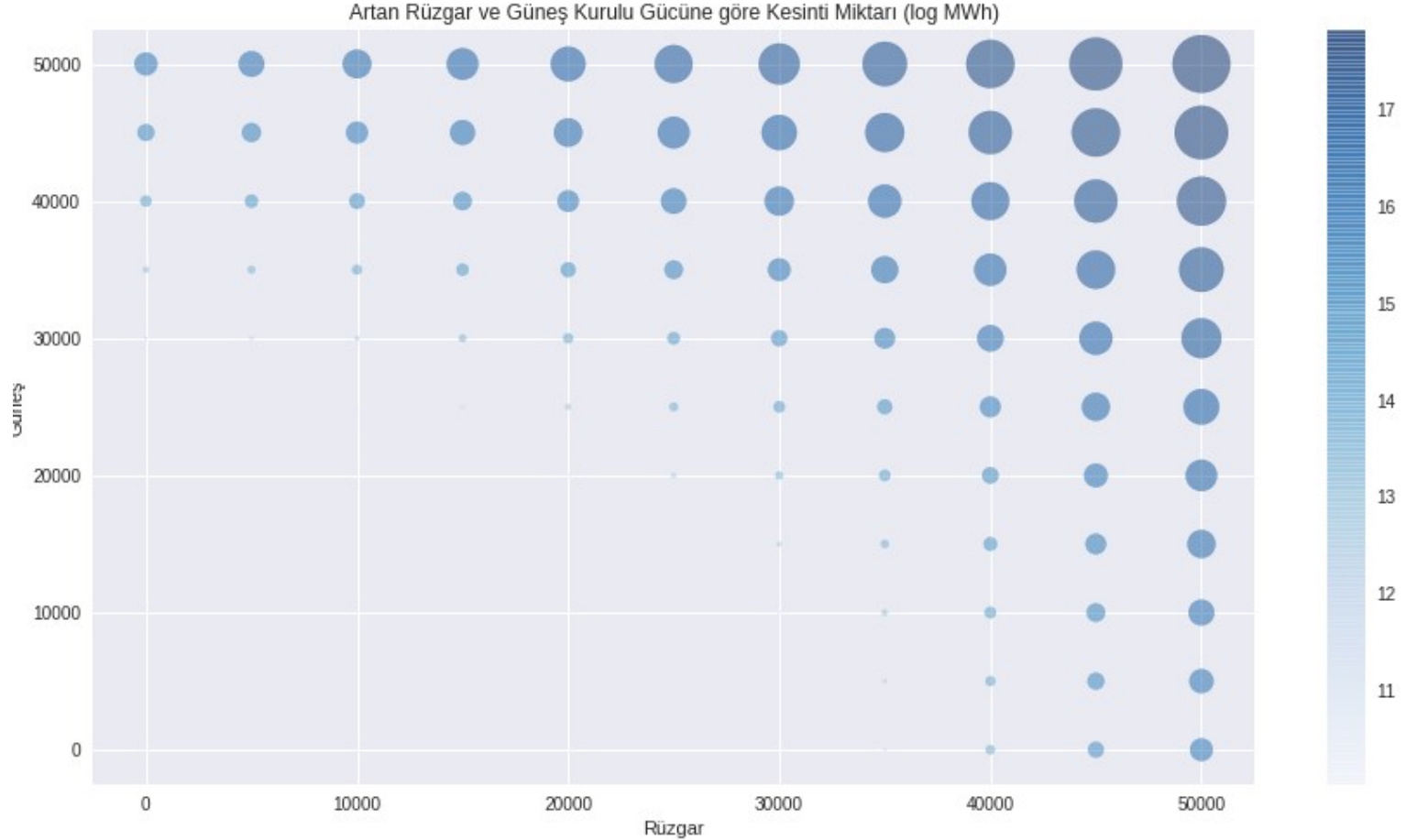
Doğal Gaz Arzı - Tahmin



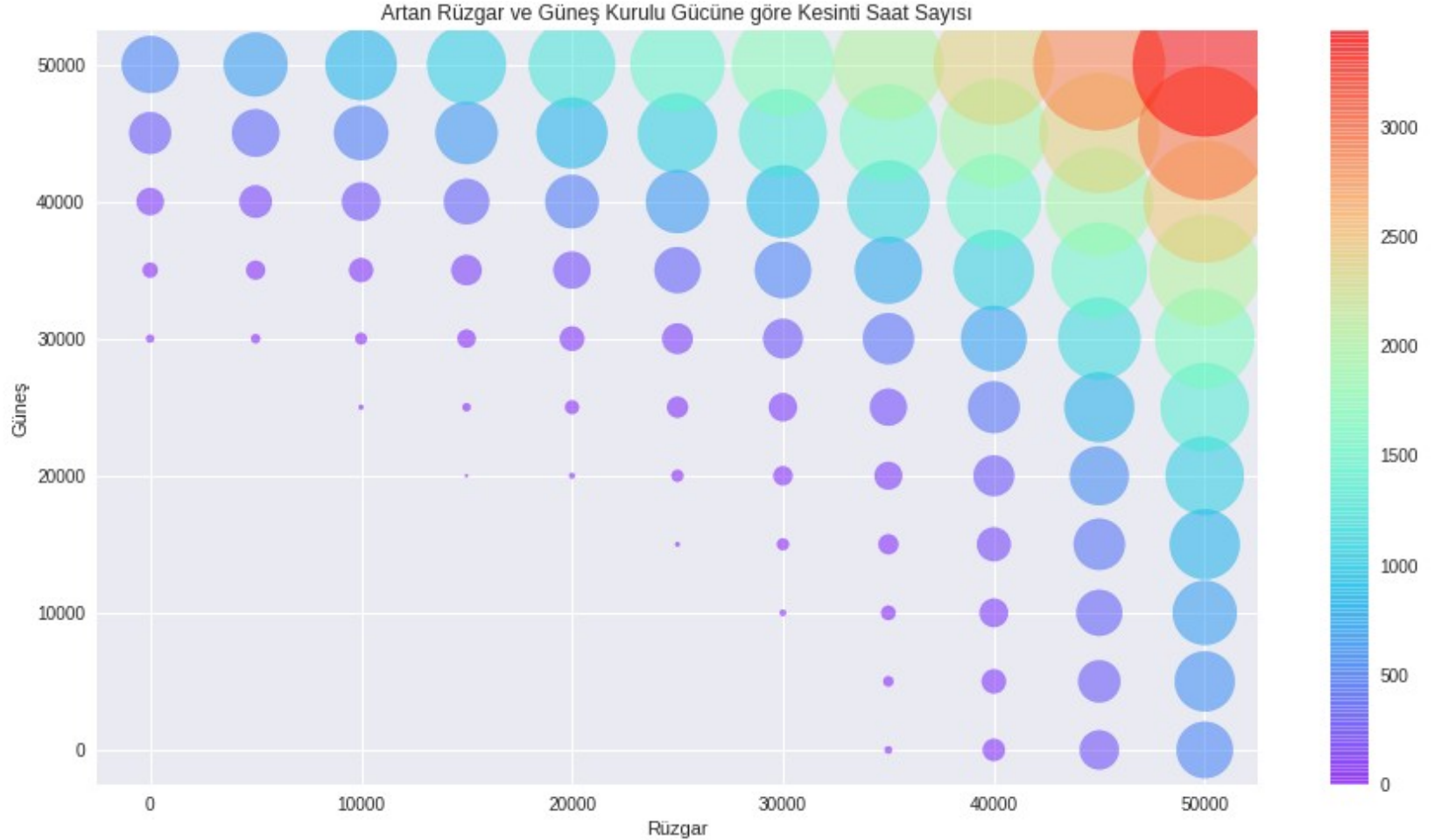
UYARI: İçerik gerçek hesaplara dayanmayıp, tartışma amaçlıdır



# Yenilenebilir artışı ile kesinti gerekliliđi

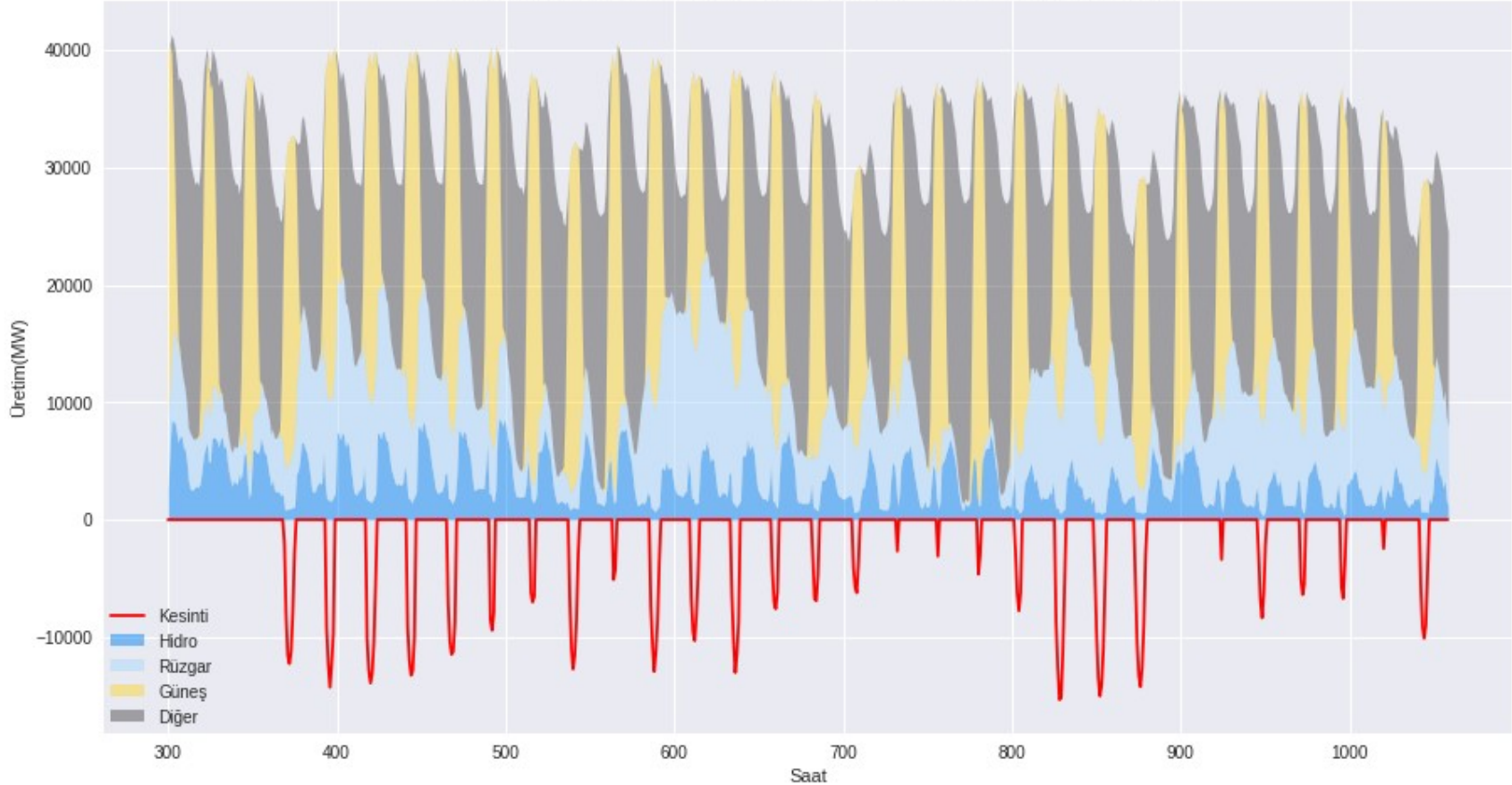


# Kesinti gereken saat miktarı



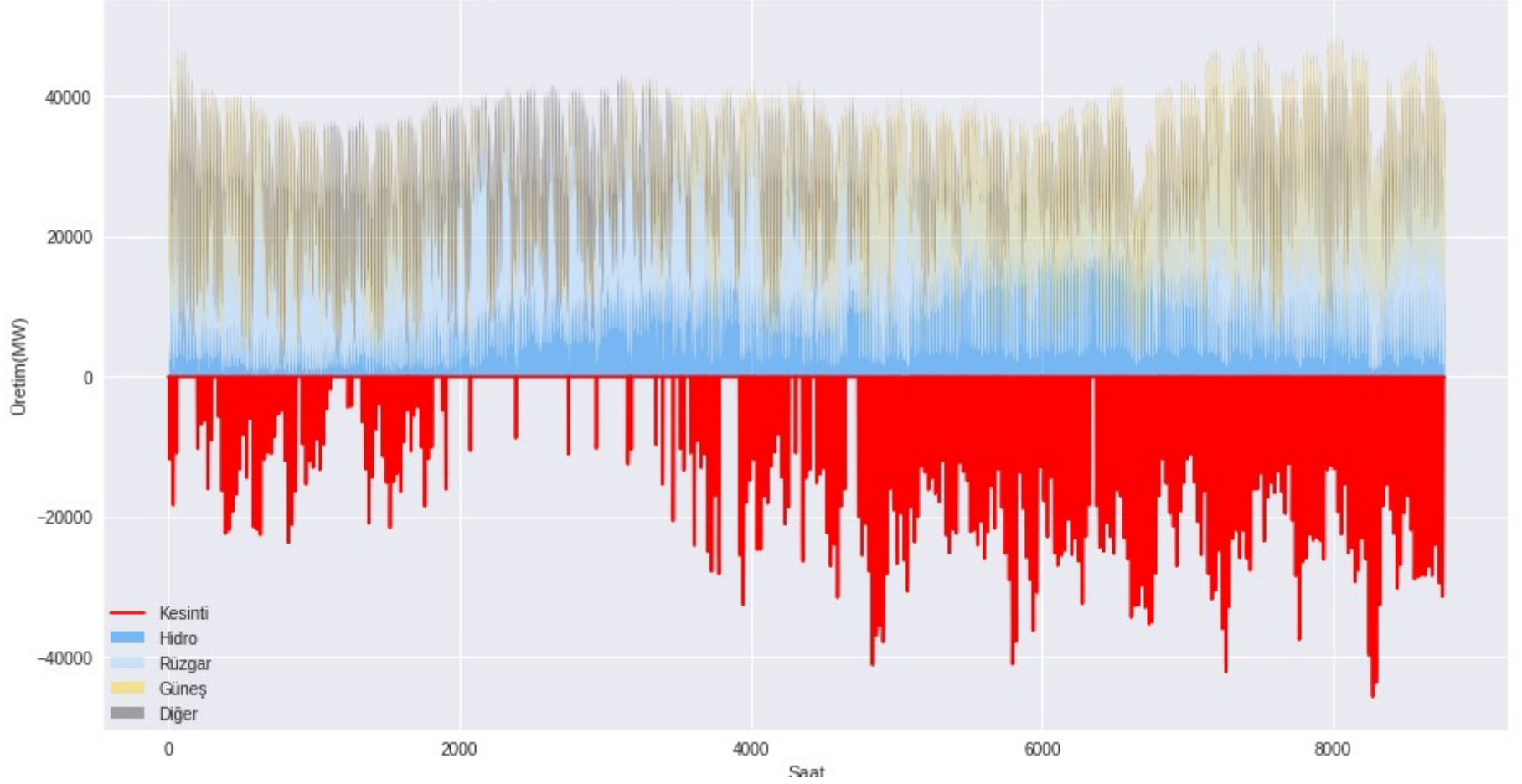
# Rüzgar 20000MW ve Güneş 50000MW

Rüzgar=20000MW Güneş=50000 MW için 300 - 1059 saatler arası üretim/kesinti



# Rüzgar 35000 MW , Güneş 50000 MW

Rüzgar=35000MW Güneş=50000 MW için 0 - 8759 saatler arası üretim/kesinti



Fazla elektrik ne olacak?

# Elektrikten diğer kaynaklara

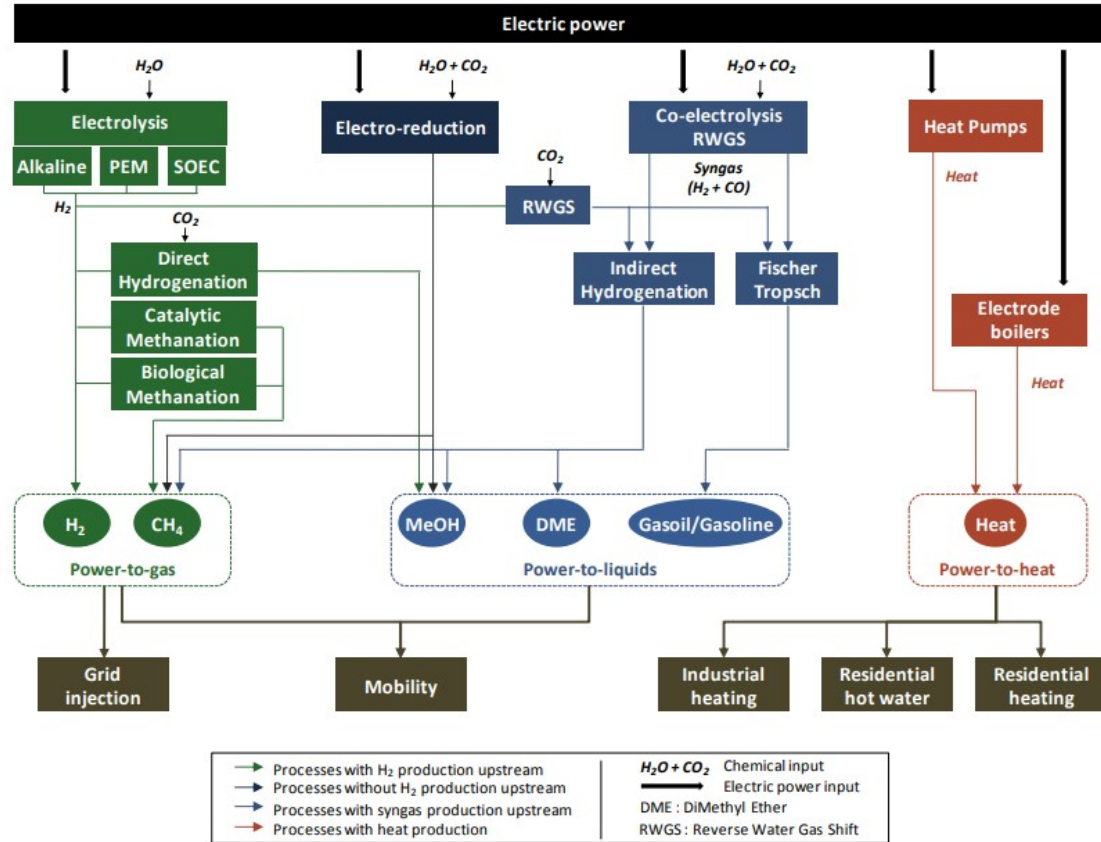


Figure 1 – Power-to-gas, power-to-liquids and power-to-heat routes and their energy markets

# Biraz Python

```
#hydrogeneurope.eu/electrolysers
```

```
kg2m3=12
```

```
def electrolyser(MWh=0,efficiency=0.6):  
    # input MWh, return kg  
    return (MWh*1000/(33/efficiency))
```

```
def fuelcell(kgHydrogen=0,efficiency=0.58):  
    #input kg, return MWh  
    return (kgHydrogen*33*efficiency)
```

```
#nrel hydrogen production cost analysis
```

```
cost_storage_per_kg =2
```

```
cost_plant_per_kg=3.7
```

```
electricity_cost_per_kWh=0.055
```

```
MWh_input=1
```

```
#per 1000 kWh=1 MWh
```

```
kg_output_per_kWh=electrolyser(1, efficiency=0.6)/1000
```

```
total_cost_per_kWh=electricity_cost_per_kWh+ (cost_storage_per_kg+cost_plant_per_kg)*kg_output_per_kWh
```

```
total_cost_per_kg_hydrogen=electricity_cost_per_kWh*1000/electrolyser(1)+cost_storage_per_kg+cost_plant_per_kg
```

```
total_cost_per_kg3_hydrogen=1000*total_cost_per_kg_hydrogen/kg2m3
```

```
def convert_electricity(MWh=0):  
    #unit conversion  
    kWh2toe=0.000086  
    electricity2methane_efficiency=0.5  
    electricity2hydrogen_efficiency=0.65  
    electricity2electricity_efficiency=0.35  
    electricity2liquid_efficiency=0.4  
    totalkWh=MWh*1000  
    totalmethane_equ=kWh2toe*totalkWh*electricity2methane_efficiency/1000000  
    totalhydrogen_equ=kWh2toe*totalkWh*electricity2hydrogen_efficiency/1000000  
    totalstoredelectricity_equ=kWh2toe*totalkWh*electricity2electricity_efficiency/1000000  
    totalliquid_equ=kWh2toe*totalkWh*electricity2liquid_efficiency/1000000  
    return (totalhydrogen_equ,totalmethane_equ,totalliquid_equ,totalstoredelectricity_equ);
```

```
# 10 TWh elektrik ne kadar metan, hidrojen, sıvı ve depolanmış elektrik eşdeğeri olur  
(h2,ch4,PtL,P)=convert_electricity(10000000)
```

```
h2 #mtoe
```

```
0.559
```

```
ch4 #mtoe
```

```
0.43
```

# Opsiyonlar

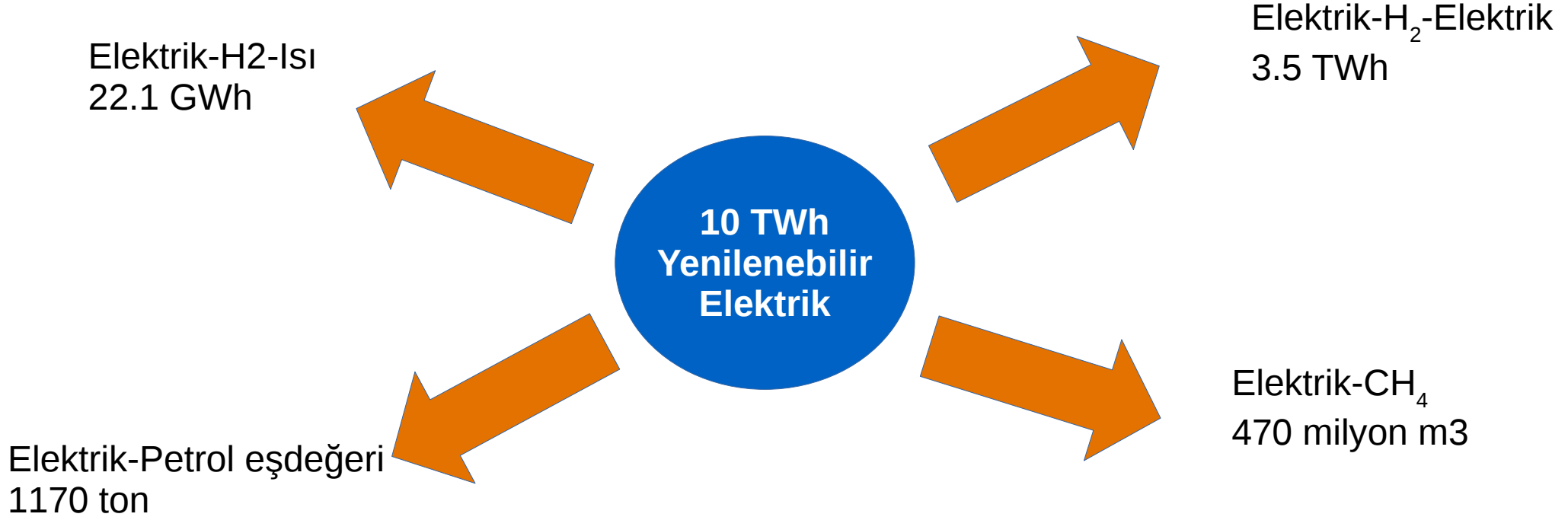
- Elektrik->Hidrojen->Depo->Elektrik  
– Yakıt hücresi (100%)  
– CCGT (50%) **%35**
- Elektrik->Hidrojen->Metan üretimi **%50**
- Elektrik->Hidrojen->Isı  
– Doğalgaza rakip **%65-80**
- Elektrik->Hidrojen->Sıvı yakıt **%40**



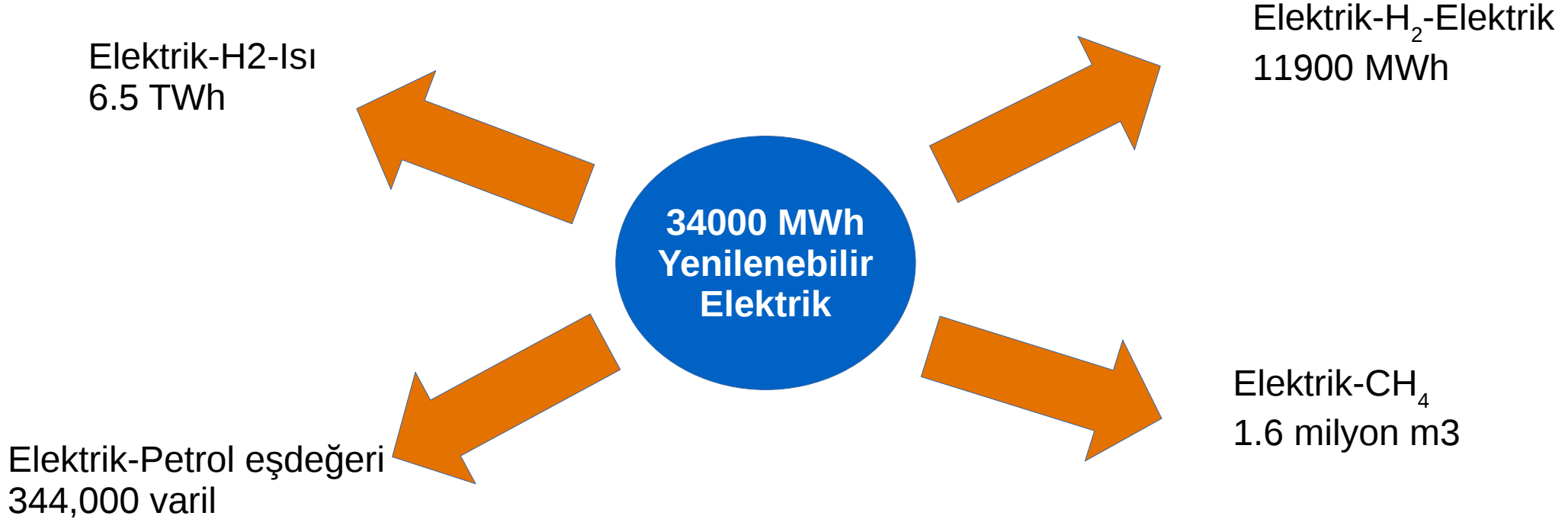
# Hidrojen üretim maliyeti

- Depolama ve diğer hizmetler 6 cent/kWh  
\$2/kg H<sub>2</sub>
- Tesis maliyeti (elektrolizör vs) 11.2 cent/kWh  
\$3.1-\$3.7/kg H<sub>2</sub>
- Elektrik maliyeti  
~ 5 cent/kWh  
-5 cent/kWh? (negatif fiyatlarda verimlilik ters çalışabilir!!)
- 17.2+elektrik << 5 (cent/kWh)

# Diğer yakıt piyasalarına etki



# Diğer yakıt piyasalarına etki(Saatlik)



# Sorular?

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# Ek – Kod 1

```
def dispatch(gunes=5400, ruzgar=7200,talep=1,kuraklik=1):
    # rezervuarlı kanal oranı 0.44
    res=gen['r']*(ruzgar/7200)
    ges=gen['g']*(gunes/5400)
    hes=gen['h']*kuraklik
    diger=gen['t']-res-ges-hes
    kesinti=pd.Series(0,range(8761))
    for i in range(8760):
        hes_dep=hes[i]/1.44
        if diger[i]<0:
            tmp=diger[i]
            diger[i]=0
            # print("HES'ten kesinti")
            if(hes_dep>=-tmp):
                hes_dep=-tmp
                hes[i]=hes[i]+tmp
            if(hes_dep<-tmp):
                kesinti[i]=-tmp
                #önce depolamalıyı azalt
                hes[i]=hes[i]-hes_dep
                tmp=hes_dep+tmp
                # print("Güneş ve rüzgar da kesinti:",tmp)
                tplm=hes[i]+ges[i]+res[i]
                hes[i]=hes[i]+(hes[i]*tmp/tplm)
                ges[i]=ges[i]+(ges[i]*tmp/tplm)
                res[i]=res[i]+(res[i]*tmp/tplm)

        #print("hes de yetmez", tmp)
    return (hes,res,ges,diger,kesinti);
```

```
ruzgar=15000
gunes=20000
(h,r,g,d,k)=dispatch(ruzgar=ruzgar,gunes=gunes)
timestart=0 #300
timerange=8759 #759
strt=timestart
stp=timestart+timerange
style.use('seaborn')
rcParams['figure.figsize']=[15,8]
pal=["#0588F6","#ADD9FD","#FFD733","#555555","#FFFFFF"]
stackplot(range(timestart,timestart+timerange),h[strt:stp],r[strt:stp],g[strt:stp],d[strt:stp],
          labels=['Hidro','Rüzgar','Güneş','Diğer','Kesinti'],
          colors=pal, alpha=0.5, edgecolor="black", linewidth=0.01)
plot(range(timestart,timestart+timerange),-k[strt:stp], color='red', label="Kesinti")
ylabel("Üretim(MW)")
xlabel("Saat")
title("Rüzgar="+str(ruzgar)+"MW Güneş="+str(gunes)+" MW için "+str(timestart)+
      " - "+str(timestart+timerange)+" saatler arası üretim/kesinti")
legend(loc=(0,0.001))
```