Open Source Natural Gas Model

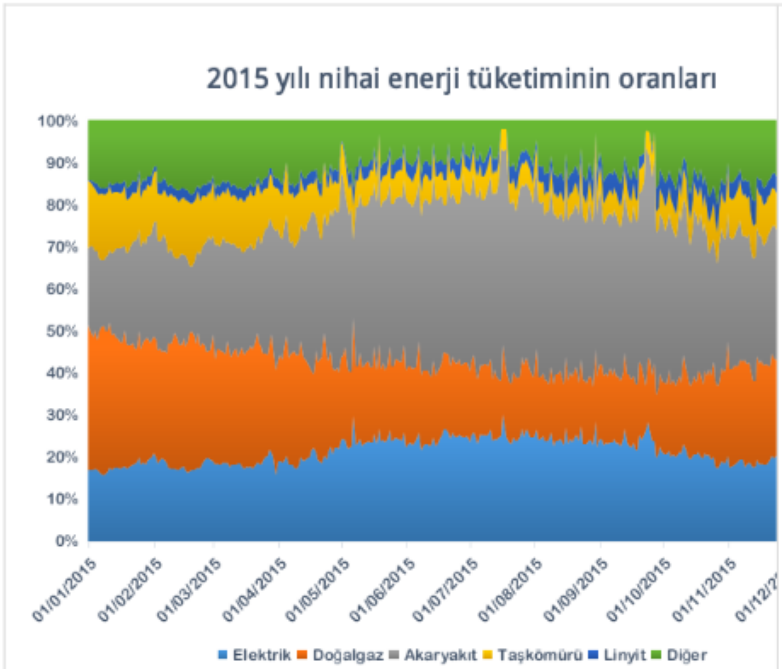
Barış Sanlı
www.barissanli.com

Contents

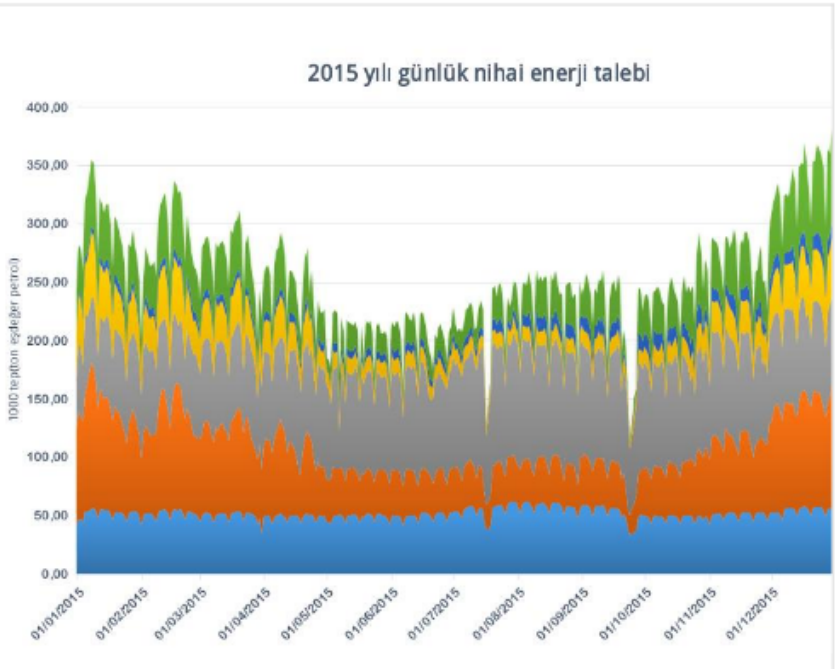
- WEC Turkey activities
- Why?
- Technical details
- Messages:
  - Can renewables set the natural gas prices?
  - Coal is not essentially in the development ladder
  - Fossil fuels are most likely
  - Price relations not strong to support nat gas
  - Infrastructure dependency
- Reports:
  - http://www.dektmk.org.tr
  - R ile enerji analizi (7 ders) : http://www.barissanli.com/calismalar/dersler/r/

Turkey’s Daily Energy Consumption

- Available online



2015 yılı günlük enerji ürünleri oranı (tahmini)

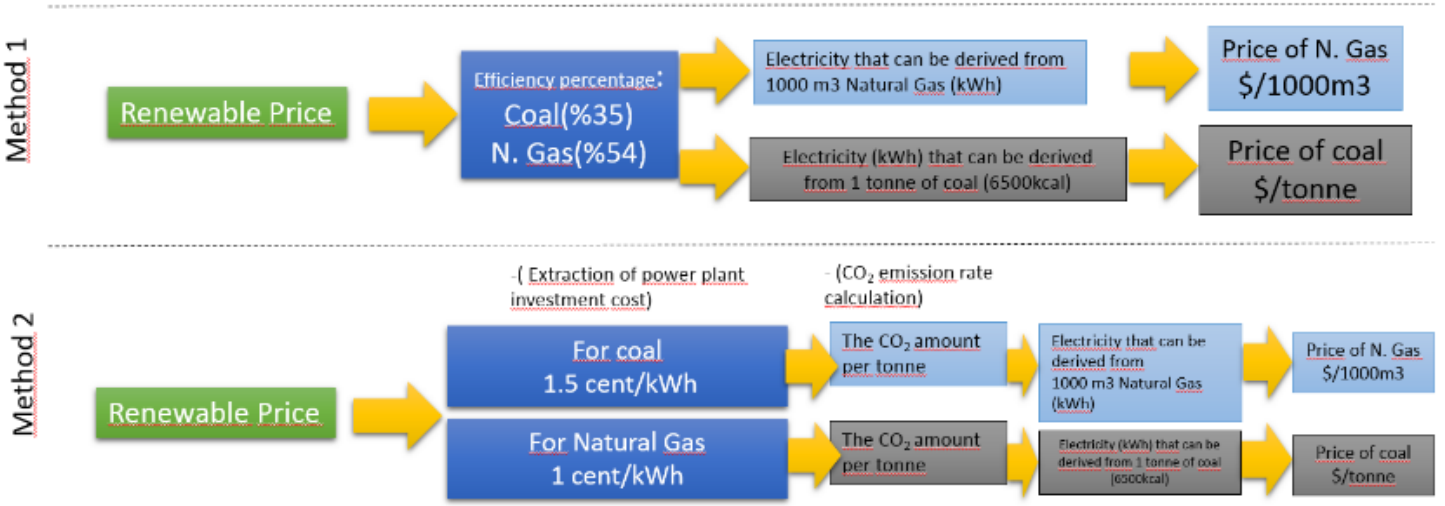


2015 yılı günlük nihai enerji talebi (tahmini)

http://www.dektmk.org.tr/upresimler/DEK-TMKQuantReportTR.pdf

What if renewables set the natural gas prices?

METHOD:



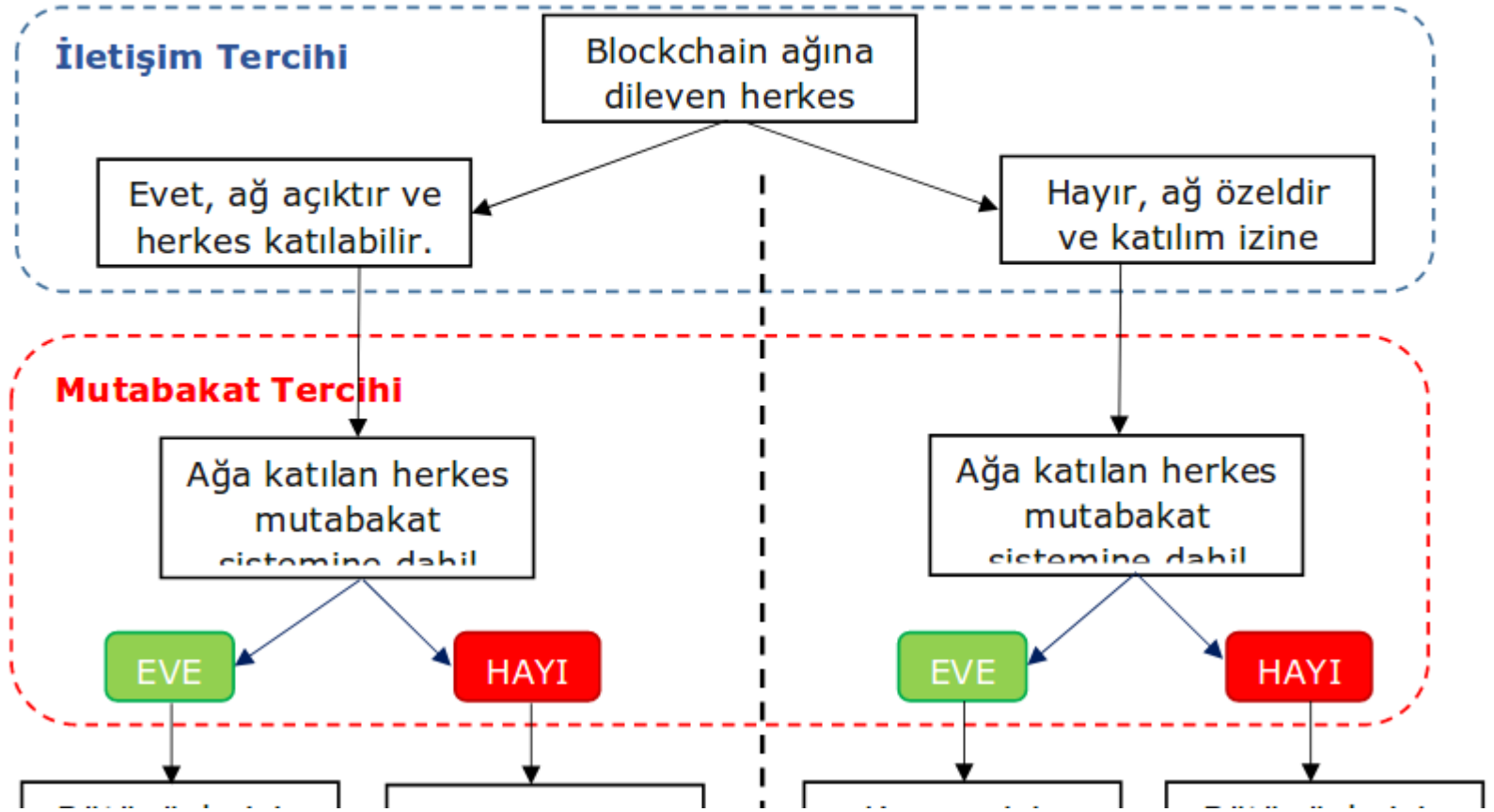
	Without investment costs		Without emission pricing		10$/tonnes CO_2 emission pricing		20$/tonnes CO_2 emission pricing	
Renewable (c/kWh)	Natural Gas ($/1000m3)	Coal ($/tonne)	Natural Gas	Coal	Natural Gas	Coal	Natural Gas	Coal
4	230	105	172	66	151	37	130	8
3,5	201	92	144	52	122	24	101	-5
3	172	79	115	39	94	11	72	-18
2,5	144	66	86	26	65	-2	44	-31
2	115	52	57	13	36	-15	15	-44

http://www.dektmk.org.tr/upresimler/DEK-TMKQuantReport2ENG.pdf

Blockchain Workshop

"KAYIT ZİNCİRİ" ÖZELLİKLERİ

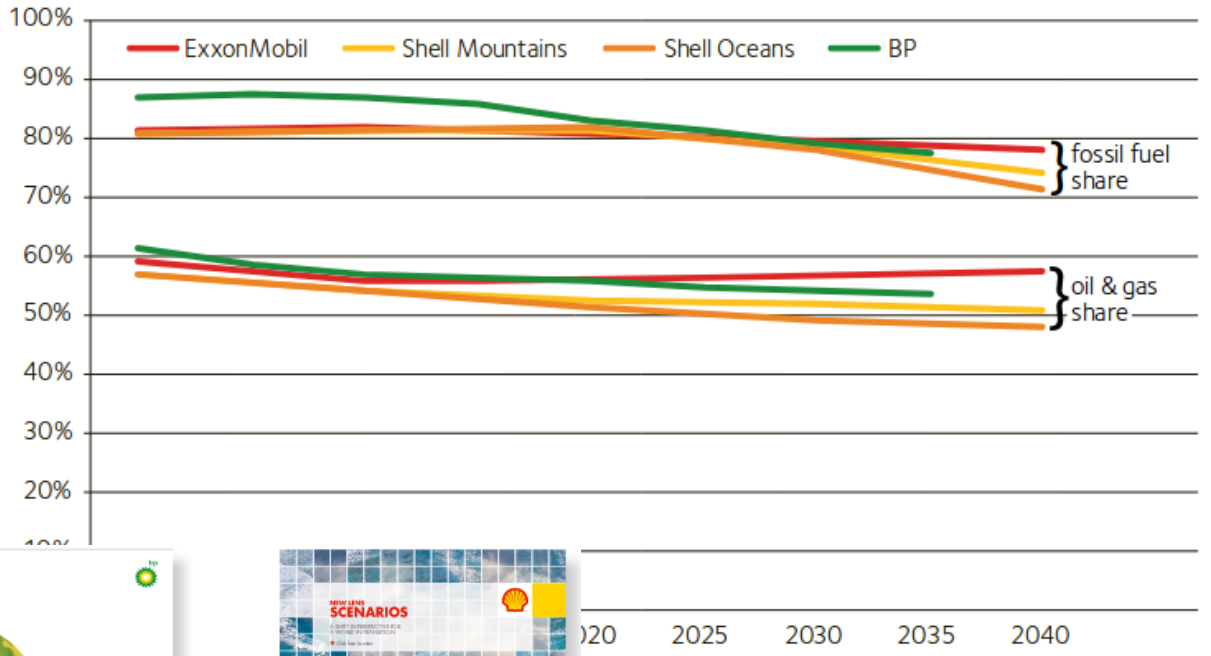
Şekil 1 - Kayıt Zinciri Özellikleri (Usta ve Doğantekin)

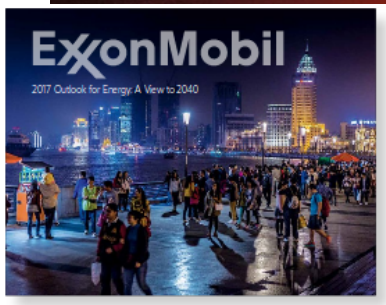


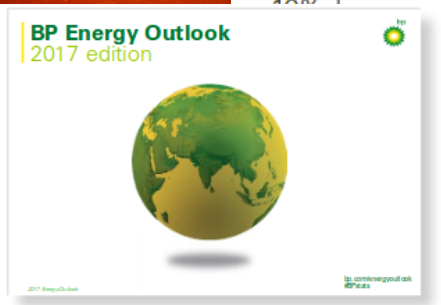
Why?

Oil Companies Believe Fossil Fuels Will Continue to Dominate the Future

Shares of world primary energy: oil company forecasts of fossil fuel share and oil & gas share[49]







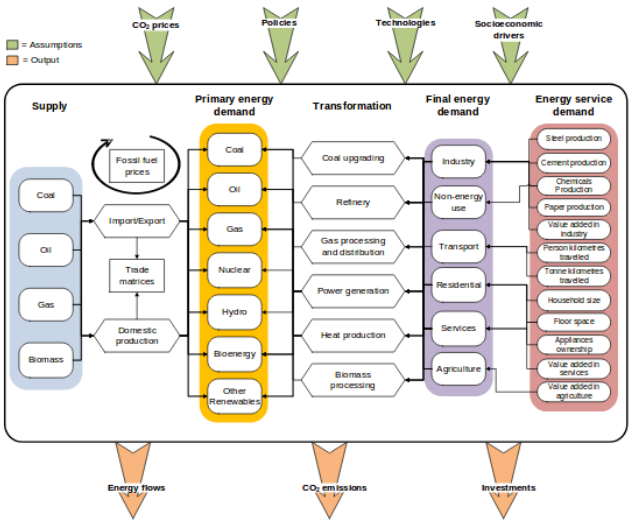
H CAUTION

https://www.greenpeace.org.uk/wp-content/uploads/2017/06/ForecastingFailureMarch2017.pdf

How modelling works?

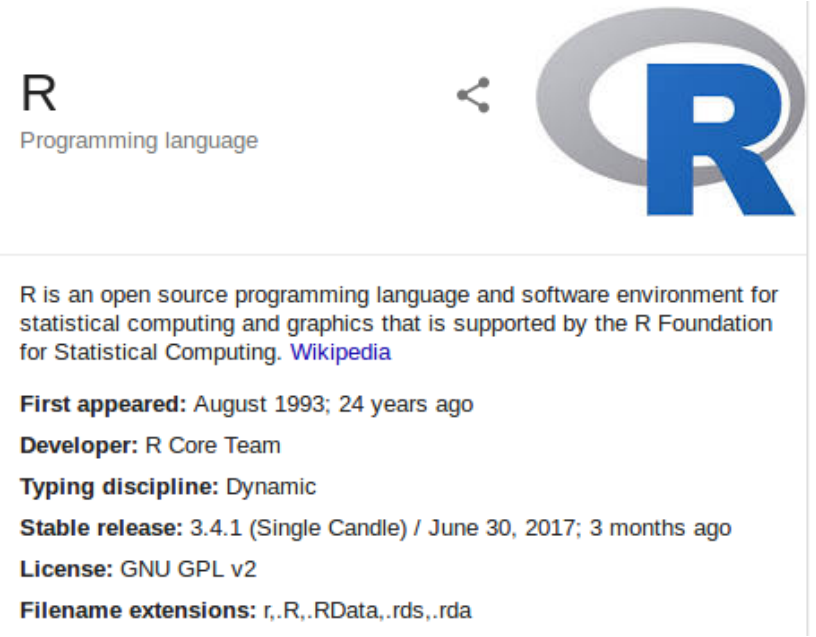
- IEA modelling workshops
- Equations=Data source+Excel+Eviews
- Costly, data access, human limits
- Numeric results + expert insight=final results

Figure 1: World Energy Model Overview

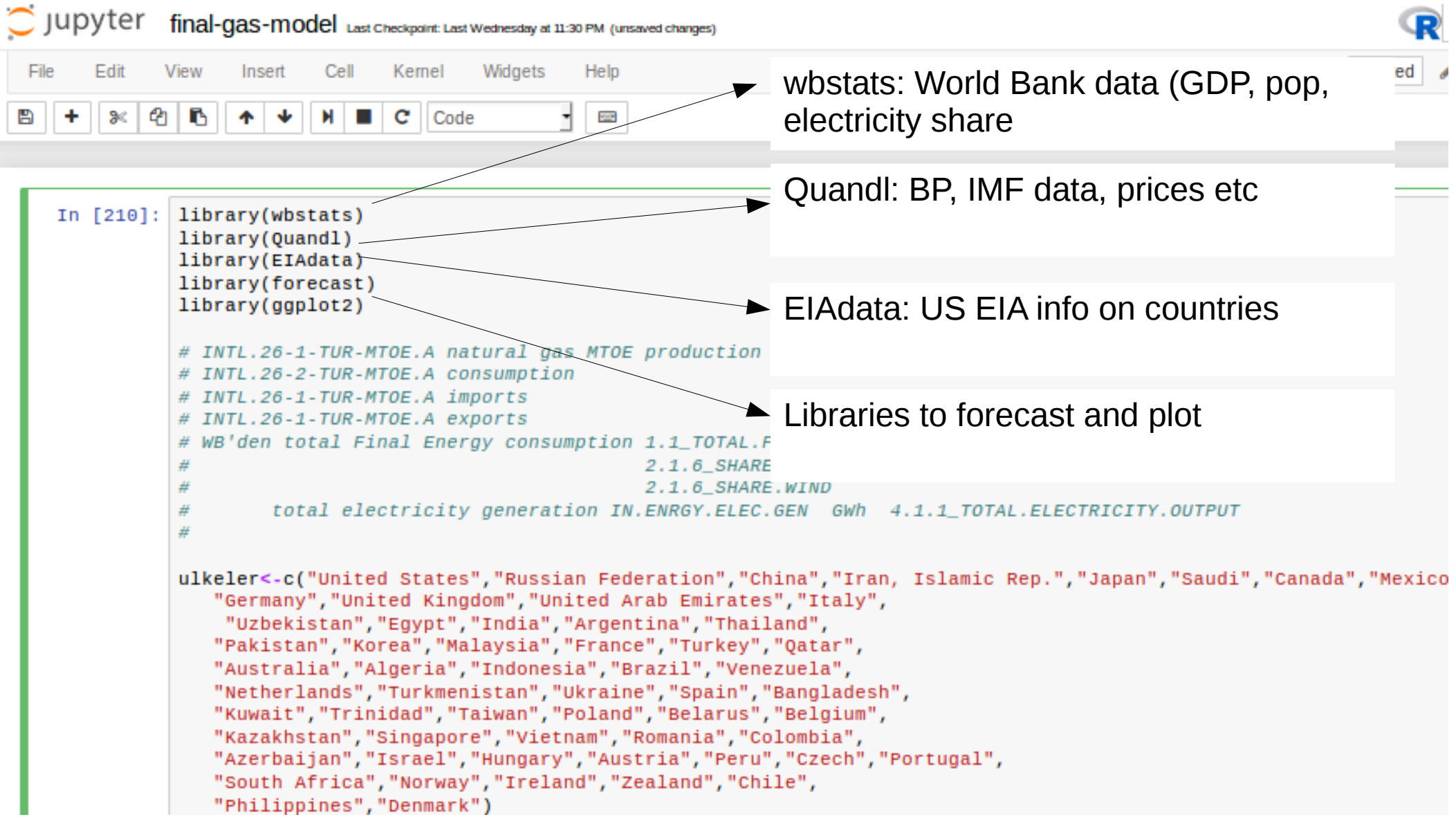


Need for dynamic, automated models

- Big data
- Excel ← data frames
- R
- Freely available sources
  - EIA data
  - IMF DB
  - Worldbank DB
  - BP Statistics



How it works?


jupyter final-gas-model Last Checkpoint: Last Wednesday at 11:30 PM (unsaved changes)
File Edit View Insert Cell Kernel Widgets Help
Code
In [210]:
library(wbstats)
library(Quandl)
library(EIAdata)
library(forecast)
library(ggplot2)
# INTL.26-1-TUR-MTOE.A natural gas MTOE production
# INTL.26-2-TUR-MTOE.A consumption
# INTL.26-1-TUR-MTOE.A imports
# INTL.26-1-TUR-MTOE.A exports
# WB'den total Final Energy consumption 1.1_TOTAL.F
# 2.1.6_SHARE
# 2.1.6_SHARE.WIND
# total electricity generation IN.ENRGY.ELEC.GEN GWh 4.1.1_TOTAL.ELECTRICITY.OUTPUT
#
ulkeler<-c("United States","Russian Federation","China","Iran, Islamic Rep.","Japan","Saudi","Canada","Mexico
"Germany","United Kingdom","United Arab Emirates","Italy",
"Uzbekistan","Egypt","India","Argentina","Thailand",
"Pakistan","Korea","Malaysia","France","Turkey","Qatar",
"Australia","Algeria","Indonesia","Brazil","Venezuela",
"Netherlands","Turkmenistan","Ukraine","Spain","Bangladesh",
"Kuwait","Trinidad","Taiwan","Poland","Belarus","Belgium",
"Kazakhstan","Singapore","Vietnam","Romania","Colombia",
"Azerbaijan","Israel","Hungary","Austria","Peru","Czech","Portugal",
"South Africa","Norway","Ireland","Zealand","Chile",
"Philippines","Denmark")
wbstats: World Bank data (GDP, pop, electricity share
Quandl: BP, IMF data, prices etc
EIAdata: US EIA info on countries
Libraries to forecast and plot

Multiple methods possible

- Linear regression
- Exponential smoothing
- AI

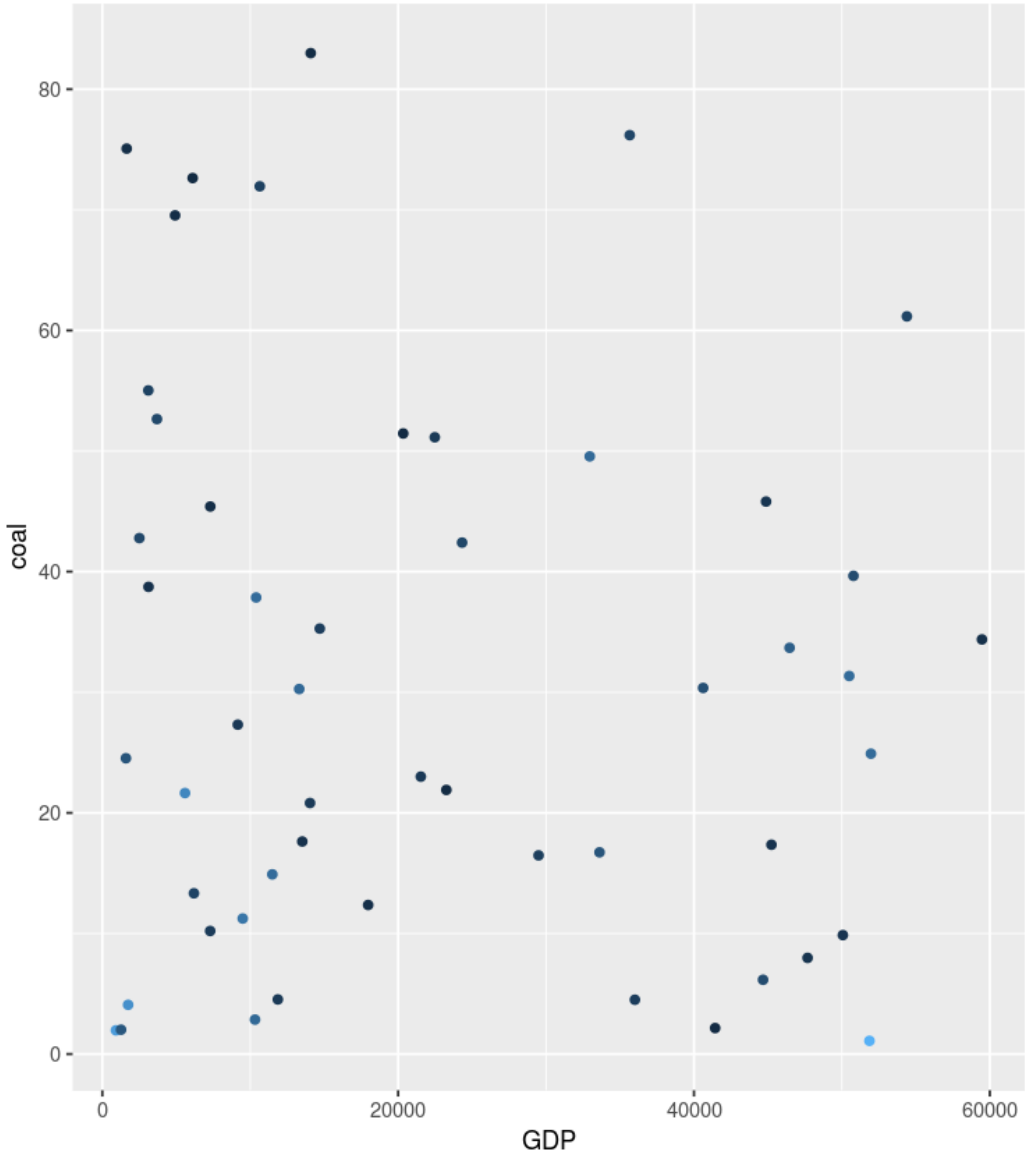
```
ana<-toplam[,sx]
fit<-ets(ana)
sonuc<-forecast(fit,h=20)
```

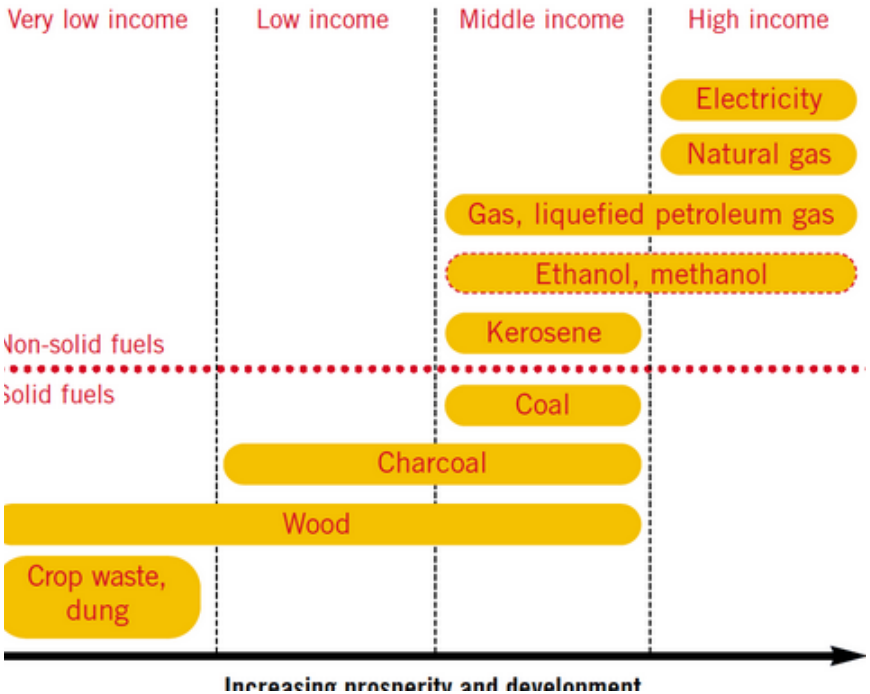
In [215]:
```
colnames(bsx)<-c("Yil",ulkeler)
tail(bsx)
```

	Yil	United States	Russian Federation	China	Iran, Islamic Rep.	Japan	Saudi	Canada	Mexico	Germany	···	Peru	Czech	Portugal	Sou Afric
[50,]	2029	690.9985	394.2755	432.3565	260.4493	169.2018	149.1149	131.8269	95.88951	73.25964	···	10.09279	6.948694	3.90002	4.4221
[51,]	2030	690.9985	394.2755	449.8413	267.0803	172.2152	152.6549	133.4505	97.81461	73.25964	···	10.17899	6.948694	3.90002	4.4221
[52,]	2031	690.9985	394.2755	467.3260	273.7114	175.2286	156.1949	135.0741	99.73971	73.25964	···	10.26519	6.948694	3.90002	4.4221
[53,]	2032	690.9985	394.2755	484.8108	280.3424	178.2420	159.7349	136.6977	101.66481	73.25964	···	10.35139	6.948694	3.90002	4.4221
[54,]	2033	690.9985	394.2755	502.2955	286.9734	181.2555	163.2749	138.3212	103.58991	73.25964	···	10.43759	6.948694	3.90002	4.4221
[55,]	2034	690.9985	394.2755	519.7803	293.6044	184.2689	166.8149	139.9448	105.51501	73.25964	···	10.52379	6.948694	3.90002	4.4221

In [217]:
```
write.csv(t(bsx), file = "MyData.csv")
```

Is there a energy ladder?





More complex analyses

- Rural and urban electricity access and coal usagein electricity


```
In [27]: data_set<-data.frame(wb_dat$coal,wb_dat$gas, wb_dat$EG.ELC.RNEW.ZS,
                             wb_dat$ruralaccess, wb_dat$urbanaccess, wb_dat$GDP)

In [28]: nasiz_veriler<-data_set[complete.cases(data_set),]

In [29]: cor(nasiz_veriler)
```

	wb_dat.coal	wb_dat.gas	wb_dat.EG.ELC.RNEW.ZS	wb_dat.ruralaccess	wb_dat.urbanaccess	wb_dat.GDP
wb_dat.coal	1.00000000	-0.2498348	-0.3924247	0.1778792	0.09448646	0.0232839
wb_dat.gas	-0.24983483	1.0000000	-0.4022186	0.2555113	0.18332611	0.3600654
wb_dat.EG.ELC.RNEW.ZS	-0.39242469	-0.4022186	1.0000000	-0.3188580	-0.24488729	-0.2730662
wb_dat.ruralaccess	0.17787919	0.2555113	-0.3188580	1.0000000	0.78807211	0.5106198
wb_dat.urbanaccess	0.09448646	0.1833261	-0.2448873	0.7880721	1.00000000	0.3607644
wb_dat.GDP	0.02328390	0.3600654	-0.2730662	0.5106198	0.36076442	1.0000000

Coal and Gas correlations?

- In all countries through all years

```
In [27]: data_set<-data.frame(wb_dat$coal,wb_dat$gas, wb_dat$EG.ELC.RNEW.ZS,
                              wb_dat$ruralaccess, wb_dat$urbanaccess, wb_dat$GDP)
```

```
In [28]: nasiz_veriler<-data_set[complete.cases(data_set),]
```

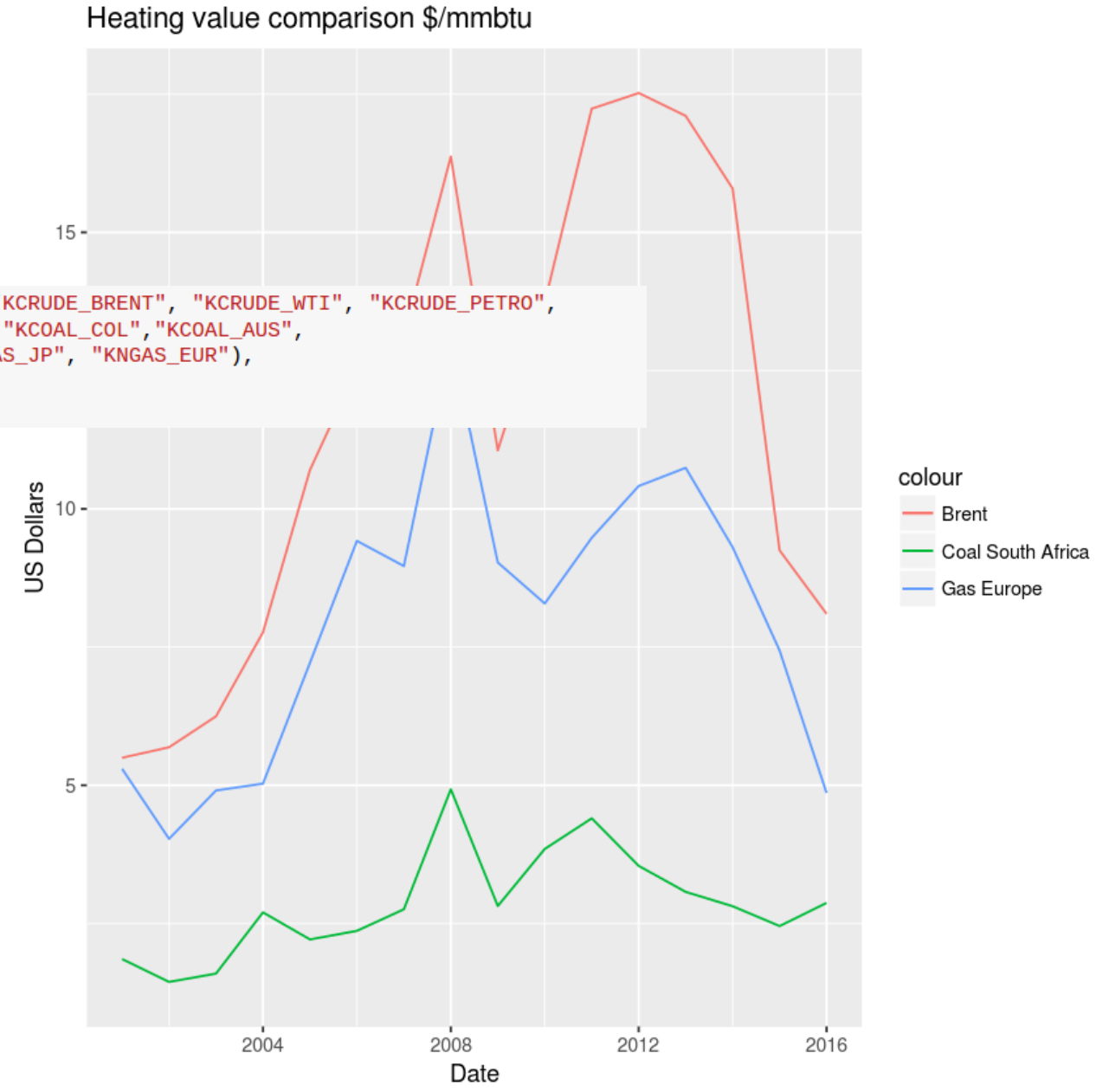
```
In [29]: cor(nasiz_veriler)
```

	wb_dat.coal	wb_dat.gas	wb_dat.EG.ELC.RNEW.ZS	wb_dat.ruralaccess	wb_dat.urbanaccess	wb_dat.GDP
wb_dat.coal	1.00000000	-0.2498348	-0.3924247	0.1778792	0.09448646	0.0232839
wb_dat.gas	-0.24983483	1.0000000	-0.4022186	0.2555113	0.18332611	0.3600654
wb_dat.EG.ELC.RNEW.ZS	-0.39242469	-0.4022186	1.0000000	-0.3188580	-0.24488729	-0.2730662
wb_dat.ruralaccess	0.17787919	0.2555113	-0.3188580	1.0000000	0.78807211	0.5106198
wb_dat.urbanaccess	0.09448646	0.1833261	-0.2448873	0.7880721	1.00000000	0.3607644
wb_dat.GDP	0.02328390	0.3600654	-0.2730662	0.5106198	0.36076442	1.0000000

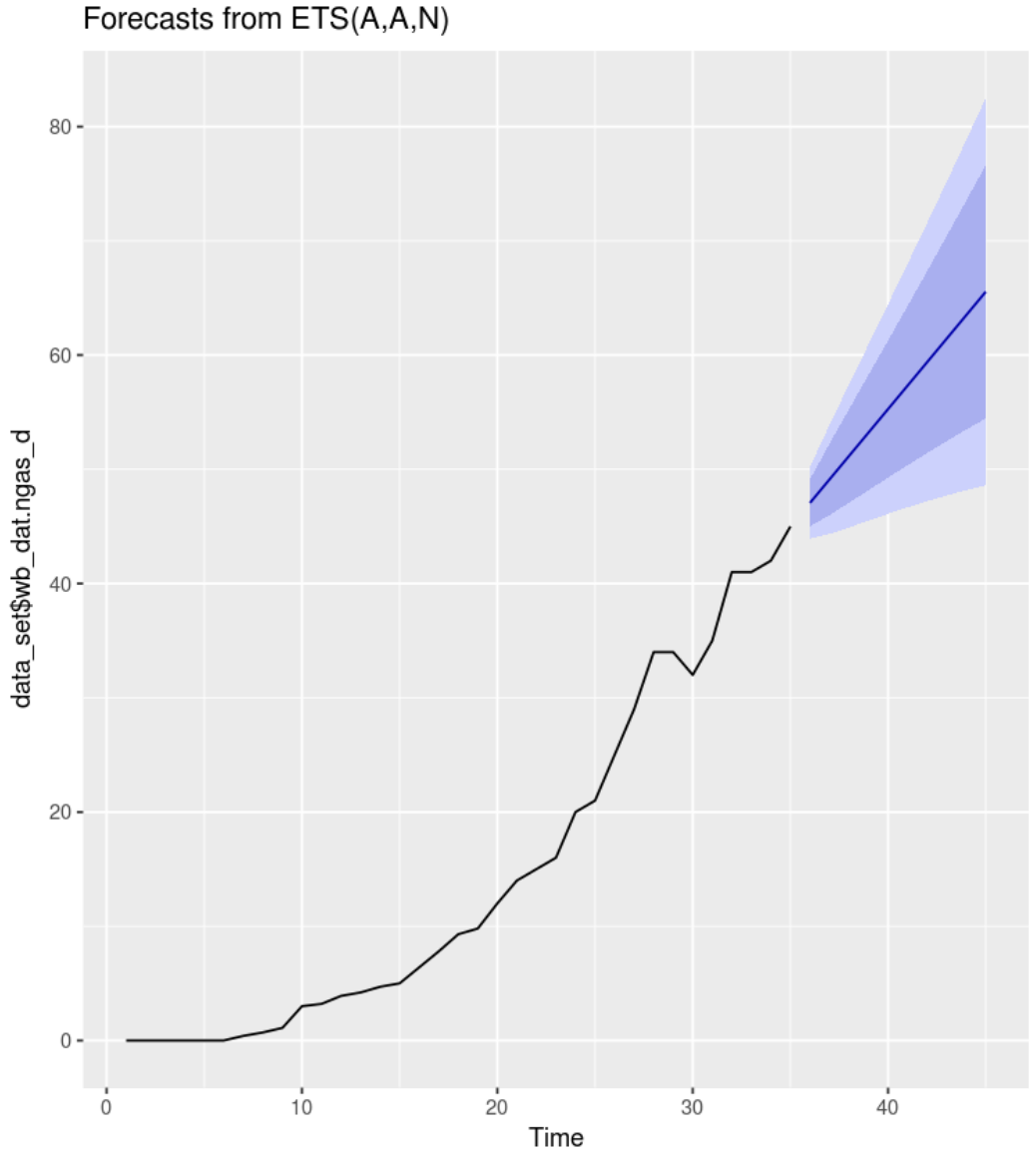
Prices?

- Monthly data available

```
en_data <- wb(indicator = c("KCRUDE_DUBAI", "KCRUDE_BRENT", "KCRUDE_WTI", "KCRUDE_PETRO",
                            "KCOAL_SAFRICA","KCOAL_COL","KCOAL_AUS",
                            "KNGAS_US","KNGAS_JP", "KNGAS_EUR"),
              #  freq = "M",
                POSIXct = TRUE)
```



Different forecast dynamics (Infrastructure effects)



By covering %95 of Global Natural Gas Demand

Market Report Series: Gas 2017

Market Analysis and Forecasts to 2022

ISBN PRINT 978-92-64-27856-1 / PD

Subject: Electricity ; Energy Market F

The natural gas market is undergoi
as the driving force behind the grov
of China, developing Asia, the Midd
supply and trade are changing the
revolution in the United States, the
and the fast-growing LNG trade ar
market players to redefine their stra

The IEA's renamed *Gas 2017* mark
infrastructure investments, and der
likely transform the gas market, le
thanks to ongoing economic grov
differences to traditional gas user
Japan.

Oversupplied markets will also kee
production and LNG liquefaction c

Edition: 2017

Type: Studies

136 pages

Table of Contents
Summary

	A	Yil	Toplam(bcm)	Toplam(mtoe)	United States
1		Yil	Toplam(bcm)	Toplam(mtoe)	United States
37	36	2015	3,476.5	3,132.0	
38	37	2016	3,521.1	3,172.2	
39	38	2017	3,565.7	3,212.3	
40	39	2018	3,610.3	3,252.5	
41	40	2019	3,654.8	3,292.6	
42	41	2020	3,699.4	3,332.8	
43	42	2021	3,744.0	3,372.9	
44	43	2022	3,788.5	3,413.1	
45	44	2023	3,833.1	3,453.2	
46	45	2024	3,877.7	3,493.4	
47	46	2025	3,922.2	3,533.5	
48	47	2026	3,966.8	3,573.7	
49	48	2027	4,011.4	3,613.8	
50	49	2028	4,055.9	3,654.0	
51	50	2029	4,100.5	3,694.1	
52	51	2030	4,145.0	3,734.3	
53	52	2031	4,189.6	3,774.4	
54	53	2032	4,234.2	3,814.6	
55	54	2033	4,278.7	3,854.7	
56	55	2034	4,323.3	3,894.9	

means that annual gas consumption almost reaches 4 000 billion cubic metres (bcm) by 2022, from around 3 630 bcm in 2016. Almost 90% of the anticipated growth in demand comes from developing economies, led by the People's Republic of China (hereafter, "China").

Discussions

- Coal – oil vs gas -electricity

  On site storage vs limited storage
- Short cycle & flexibility era

  shale, solar, LNG...
- Renewables may eat the share of elec growth
- Coal scarcity vs LNG glut
- Policy support (Coal brings employment but air quality, Nat Gas +)
- Geopolitics
  - Narrative: Asia → center of gravity, US,Australia, Qatar
  - Nat gas development speed is constrainted by infra

Thank you

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