

HYDROPOWER DEVELOPMENT IN TURKEY

By

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Turkey

- **Area:** 783,600 km²
- **Population:** 78,151,750 (2015)
- **Installed hydropower capacity:** 43,1331 MW (megawatt) (2015)
- **Hydropower generation:** 67 billion kWh (2015)

HISTORY

- The first hydroelectric plant in Turkey was constructed at Tarsus in 1902.
- This plant only produced 60 kW, but nonetheless was a great technical achievement for the country.



HISTORY

- In later years there were many more projects including: Seyhan, Sariyer, Hirfanli, Kesikköprü, Demirköprü, and Kemer.
- These projects were either dams or hydroelectric power plants and **by 1940** there were a total of **28 hydroelectric** power plants in Turkey.
- After the **State Hydraulic Works** (DSI) was established **in 1954** projects were better funded and the power produced per year was greatly increased.

World Hydropower Potential

- According to the Hydropower & Dams Atlas (H & D, 1999), **world** hydro potential is as follow:
- **Gross** hydro potential: 40,500 TWh/year
- **Technically feasible**: 14,300 TWh/year
- **Economically feasible**: 8,100 TWh/year

Currently, only **four facilities** over 10 GW (10,000 MW) are in operation worldwide

Rank	Station	Country	Location	Capacity (MW)
1.	Three Gorges Dam	 China	 30°49'15"N 111°00'08"E	22,500
2.	Itaipu Dam	 Brazil  Paraguay	 25°24'31"S 54°35'21"W	14,000
3.	Xiluodu Dam	 China	 28°15'35"N 103°38'58"E	13,860
4.	Guri Dam	 Venezuela	 07°45'59"N 62°59'57"W	10,200

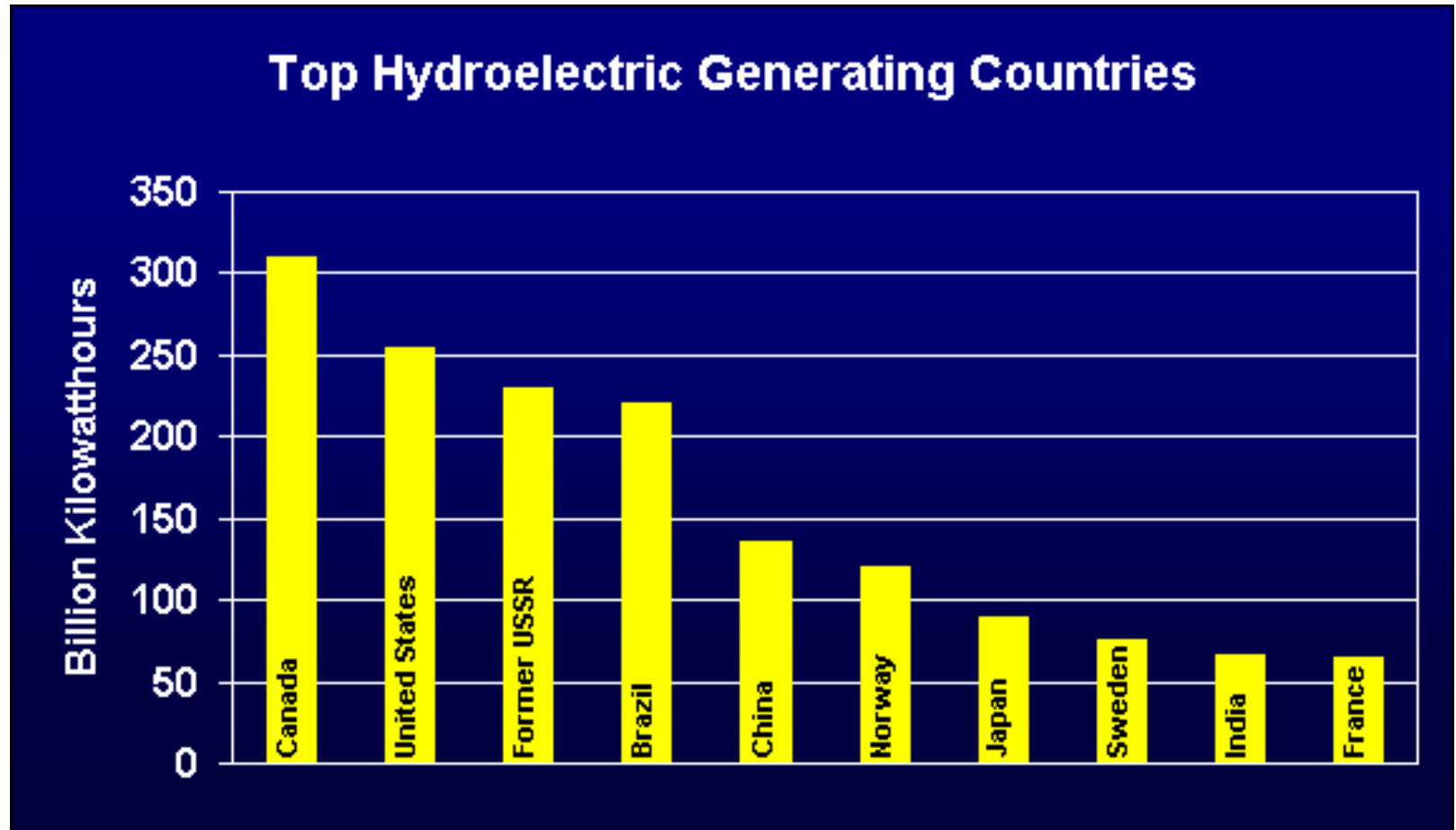
Countries with the most Hydroelectric Capacity

- Hydroelectricity is one of the most important sources of energy in the world.
- Many countries in the **Nordic region** and **South America** are **almost completely** dependent on hydro power for their energy needs.
- **Venezuela, Norway** and **Paraguay** are almost **100%** dependent on hydro power.
- Paraguay due to the Itati Dam exports a massive portion to neighbouring countries as well.
- **Brazil, Switzerland, New Zealand** are some other countries with a very high percentage of hydro power.

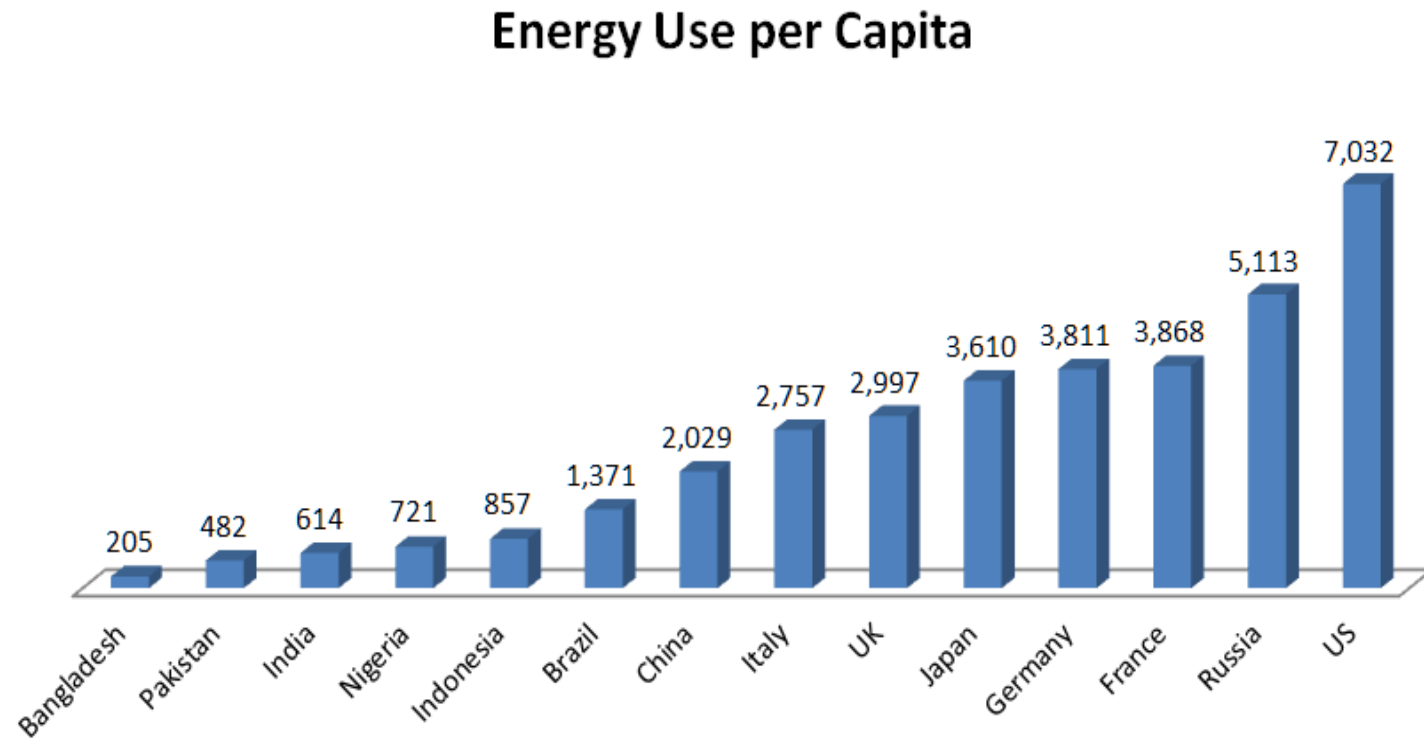
The largest installed capacities of hydroelectricity in countries (2011)

• China:	200 GW
• Canada:	89 GW
• USA:	80 GW
• Brazil:	70 GW
• Russia:	45 GW
• India:	33 GW
• Norway:	27 GW
• Japan:	27 GW
• Venezuela:	15 GW

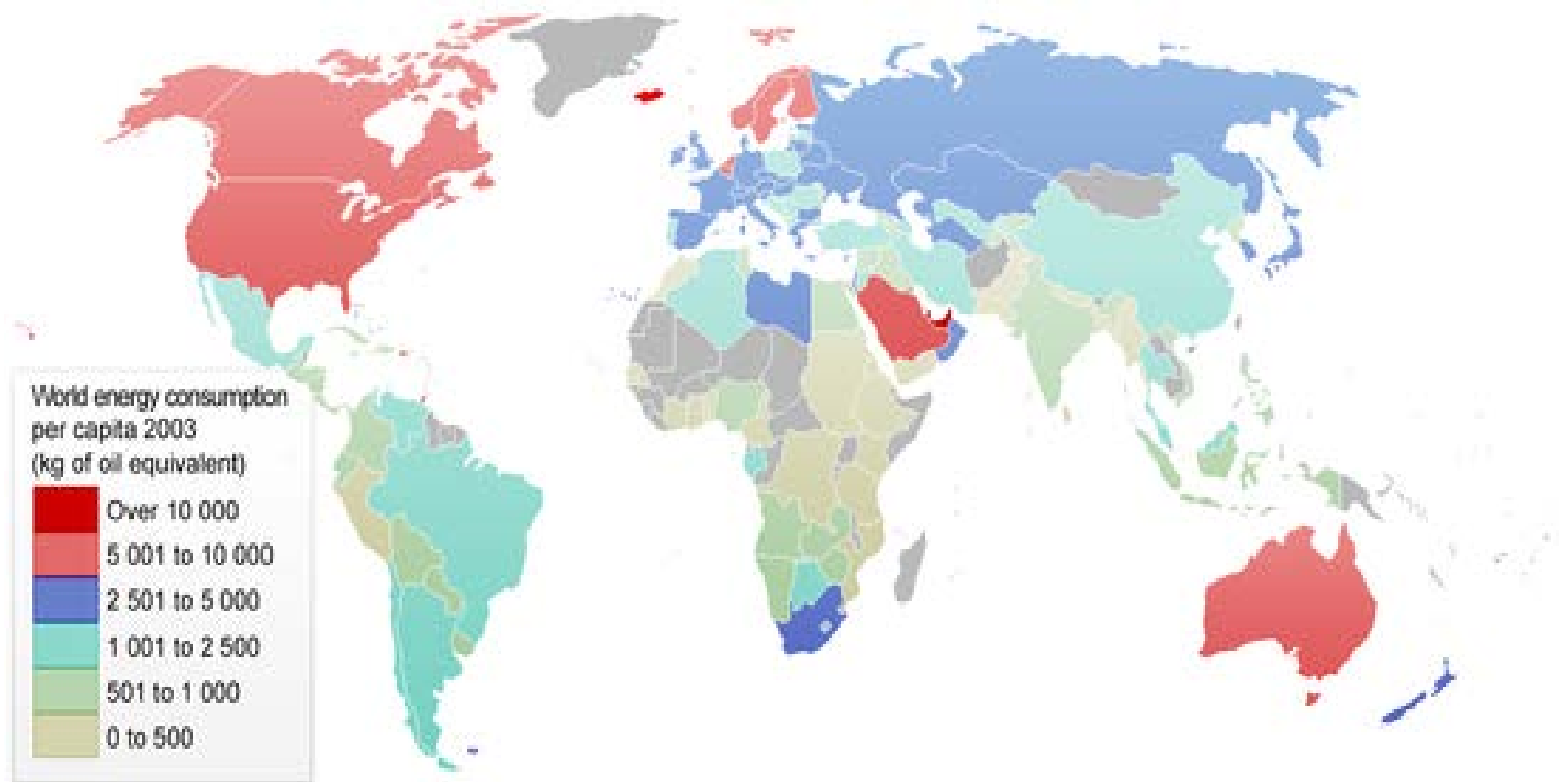
Top Hydroelectric Generating Countries

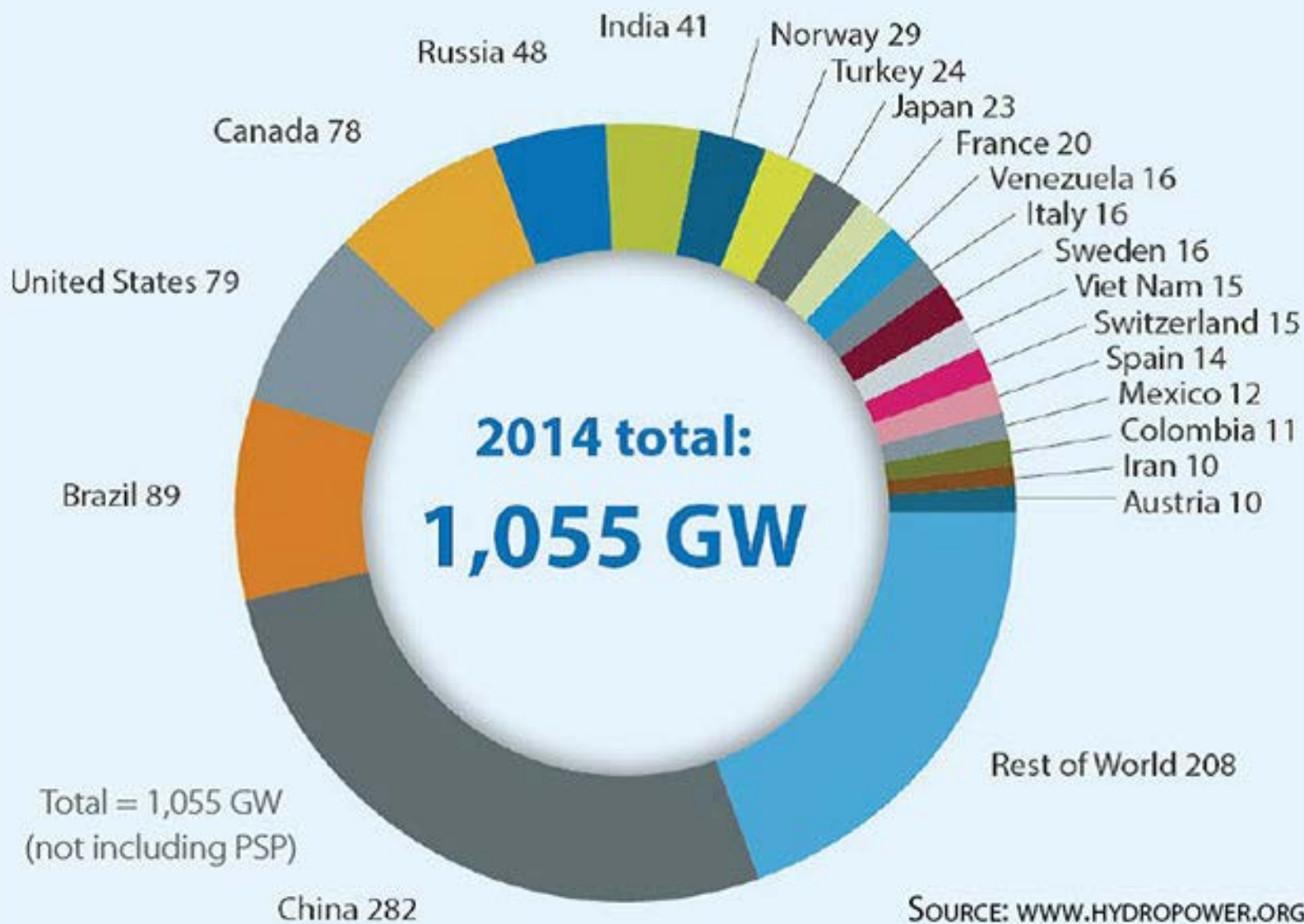


Energy use per capita by counties



World energy consumption per capita, 2003

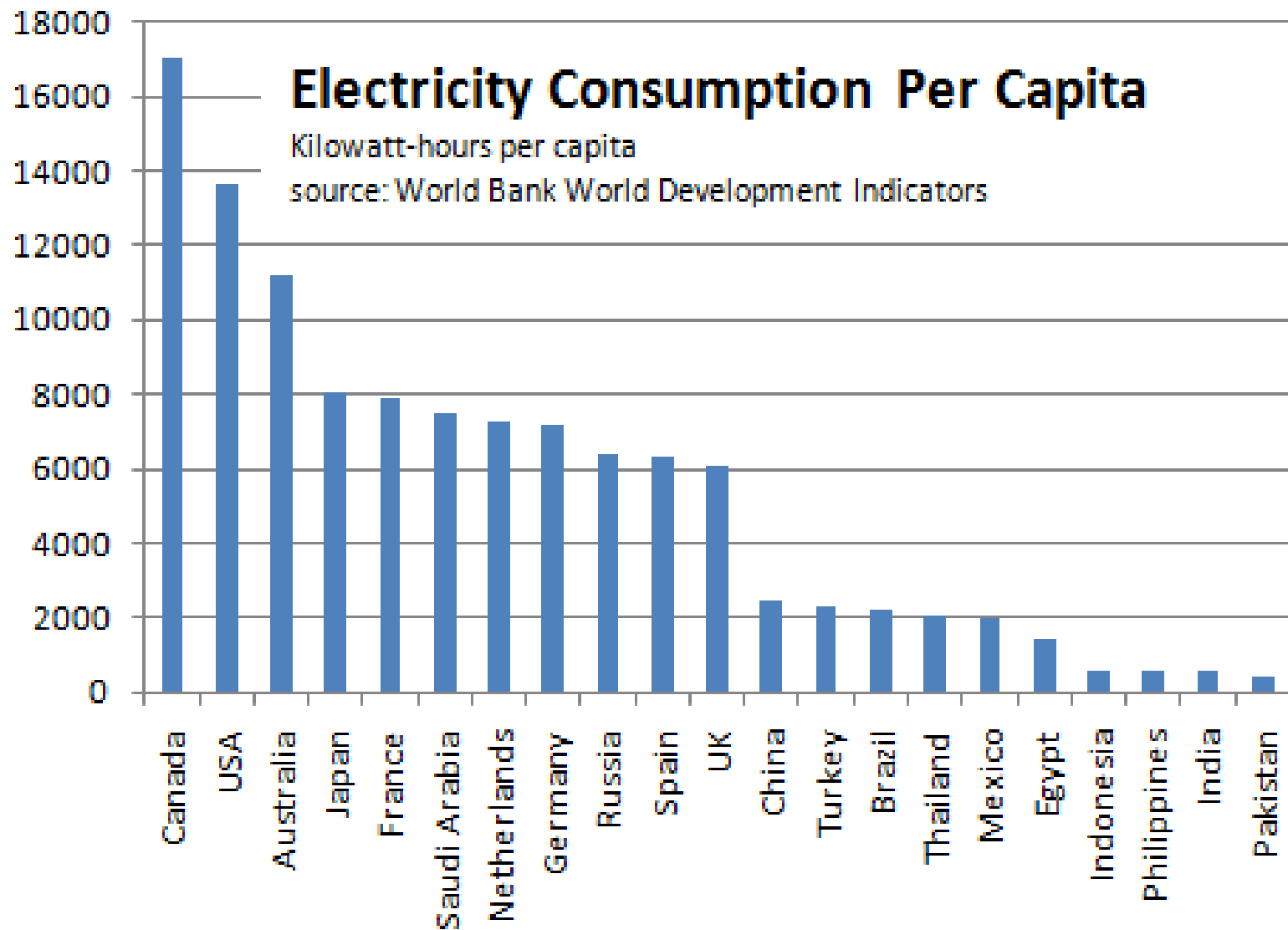




Electricity Consumption Per Capita

Kilowatt-hours per capita

source: World Bank World Development Indicators



Energy **production** and **consumption** in Turkey (mtoe)
(Million tonnes of oil equivalent.)

Energy sources	Energy produced	% of total production	Energy consumption	% of total consumption
Coal and lignite	21.22	62.50	36.24	26.87
Oil	1.58	4.65	41.68	30.90
Natural gas	0.56	1.65	46.37	34.39
Com. renewable and wastes	5.26	15.50	5.26	3.88
Nuclear	—	—	—	—
Hydropower	4.32	12.72	4.32	3.20
Geothermal	0.73	2.15	0.73	0.55
Solar/wind/other	0.28	0.83	0.28	0.21
Total	33.95	100	134.82	100

Precipitation volume of Turkey

- The country has a volume of some **186 km³/year** of water flowing through its 177,000 km of rivers.
- It is only following measures **to privatize** the national electricity system began in **2003** that the exploitation of this huge resource began to **accelerate**.
- Today, though some **60% of the country's** hydropower potential remains undeveloped.

Turkey's Water Potential

- With respect to the situation in this country, contrary to the general perception, Turkey is neither a country **rich** in freshwater resources nor the **richest** country in the region in this respect.
- Turkey is situated in a **semi-arid region**, and has only about **one fifth** of the water available per capita in water rich regions such as North America and Western Europe. Water rich countries are those which have **10.000 cubic meters** of water per capita yearly.
- This is well above **the 2.000 cubic meters per capita in Turkey**

- Another point is that Turkey's water is not always in **the right place at the right time** to meet present and anticipated needs.
- Certain regions of Turkey such as the **Black Sea** region have ample but unusable freshwater, while some of the more heavily populated and industrialized regions such as the **Marmara** and the **Aegean** regions **lack sufficient fresh water**.

TURKEY'S HYDROPOWER CAPACITY

- Benefitting from its mountainous landscape and position between **three seas**.
- Turkey has a significant hydropower capacity, estimated at some **433 TWh a year in total**, of which some **166 TWh a year is thought economically viable** (2015).

Advantage of geography

- At an average elevation of **1100 meters** above sea level, there is ample head available for development in a number of regions, including the area around the **Black Sea**, the **Mediterranean**, and **Eastern Anatolia**
- The geography provides considerable opportunity for hydropower development.

River Basins in Turkey



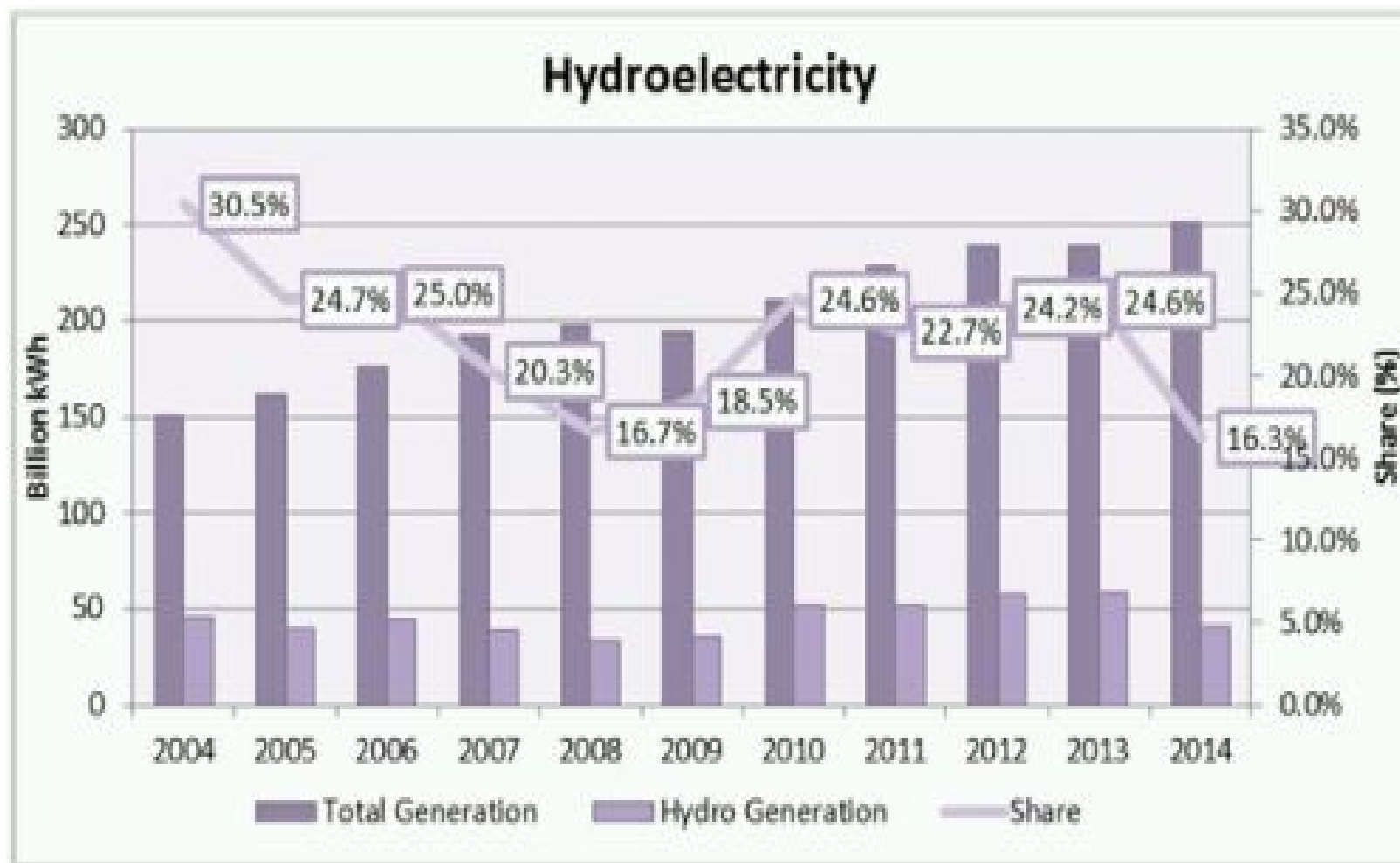
Physical map of turkey



Turkey's Dependence On Water For Energy

- Turkey produces more than 67 billion kWh of hydroelectric power per year (Electricity Generation Co. Inc. (EÜAŞ)-2015), which corresponds to **25,6% of its total power** generation (2015).
- Turkey's energy consumption is rising about **5.7 percent a year** on average **due to rapid urbanization and industrialization**.
- **In 2002**, the electricity consumption peaked at **126.9 billion kWh**,
- In **2015** **264 billion kWh**.
- It is estimated to rise to **528 billion kWh** in 2020.

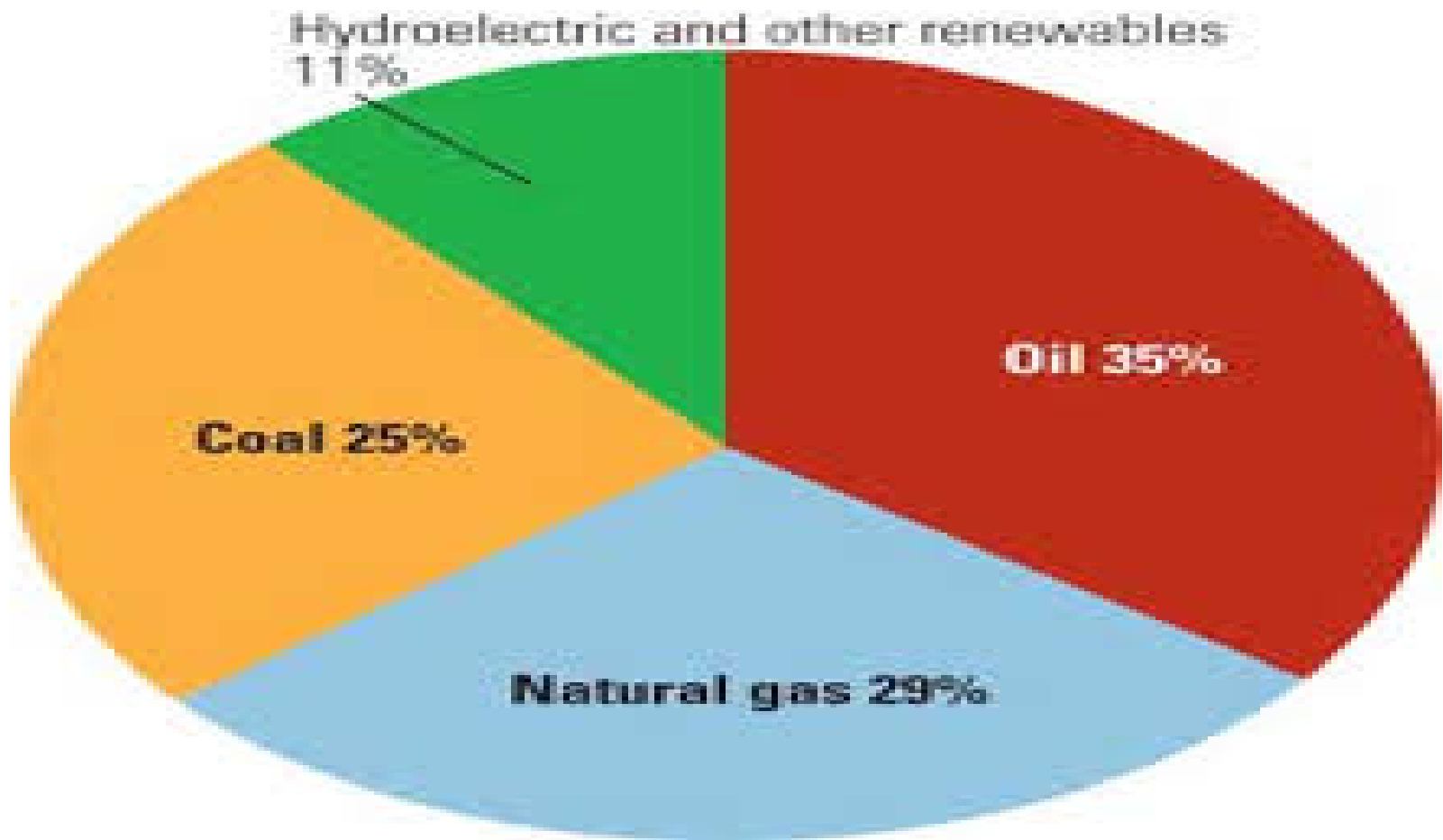
Hydroelectricity



In 2015 (31.12.2015) Electrical production (264 billion kWh)

<u>Natural gas</u>	98.353.407	37.88 %
Coal	68.844.330	26.52 %
<u>Hydroelectric</u>	66.869.948	25.76 %
<u>Wind</u>	11.540.813	4.45 %
<u>Geothermal</u>	3.267.856	1.26 %
Other thermal	10.739.245	4.14 %

Hydroelectric and other renewables



- Furthermore, electricity demand in Turkey is forecast to grow by more than **90 per cent over the next ten years**, adding to the suite of drivers for hydropower development.

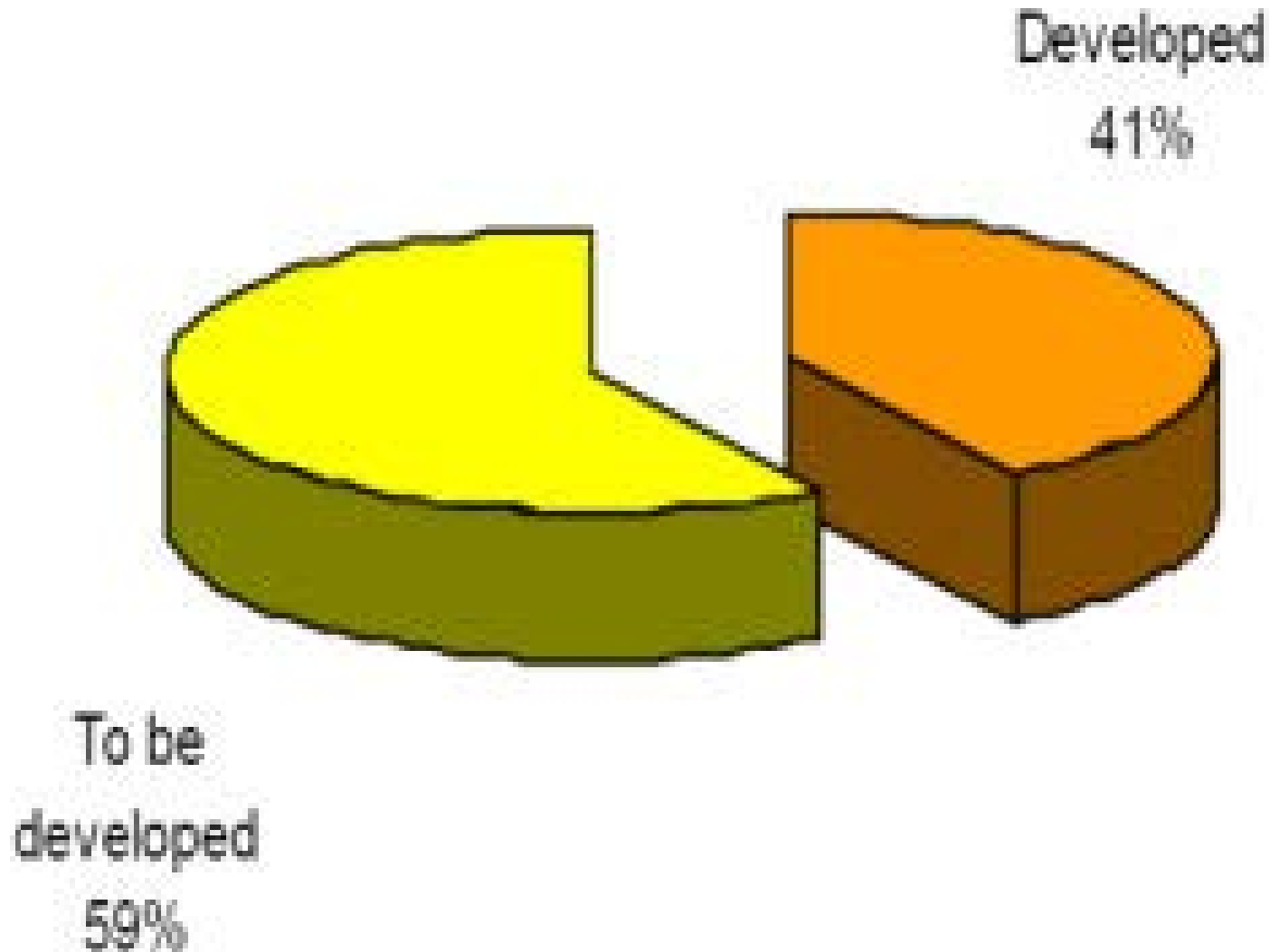
Purposes

- Turkey has ambitious plans for **hydropower** over the **coming decade**. The country is aiming to mark its **100 years** as a republic in **2023** with a total installed electric power capacity of 100 GW – up from 32 GW in 2002 and 64 GW in 2014 – with **30 per cent of electricity generation** coming from **renewables**.

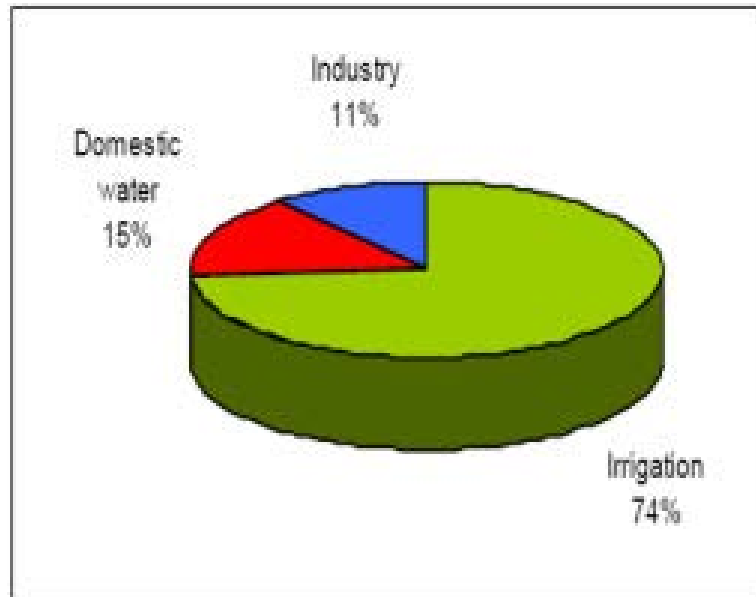
- The country is pushing ahead with its formidable goal to exploit all of its estimated **166,000 GWh/year** of economical hydropower potential, which would include an expected total of about **24,000 hydropower** plants (including small hydro plants).

- To date (2015), **roughly 41 percent** of this potential has been tapped, with a further **15 percent under construction**, leaving the country with some way to go in achieving its target.
- At the end of 2015, Turkey's installed hydropower capacity was 43 GW, producing 67 billion kWh/year of electricity

Developed Hydropower (%) (2015)



WATER USED



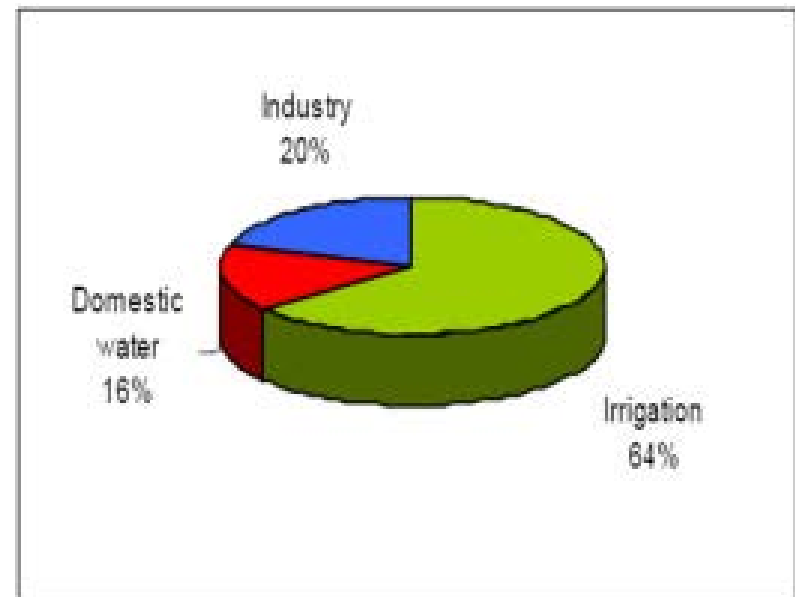
2008

Irrigation : 34 billion m³ (74%)

Domestic water : 7 billion m³ (15%)

Industry : 5 billion m³ (11%)

TOTAL : 46 billion m³



2023

Irrigation : 72 billion m³ (64%)

Domestic water : 18 billion m³ (16%)

Industry : 22 billion m³ (20%)

TOTAL : 112 billion m³

- Turkey has a suite of policies that will support hydropower development, including a 30 per cent target for renewables by 2023, a feed-in-tariff for projects completed by the end of 2015, VAT (Value Added Tax) and customs exemptions, and licence fee exemptions for renewable projects.

- In early **2015**, the Turkish Government announced it would allocate **USD 16 billion to hydro development until 2018** as part of its Tenth Development Plan.
- In addition, deregulation of the power sector has encouraged **private investment**, with independent power producers taking on the bulk of new developments.

INTERCONNECTIONS

- Hydropower development will be further supported by Turkey's interconnections into the European grid and potential for further linkages east into Asia.

PRIVATISATION

- In 2003, Turkey liberalised its energy market and embarked on a process of privatising existing assets as well as attracting private sector investment into new projects, although several strategic hydropower facilities will be exempted from **the privatisation** programme.
- In recent years, **E.ON** and **Statkraft** have made major investments in the country, while **China** has engaged through a plan to develop hydropower with local companies.

Largest hydropower stations in Turkey

- **Name Power Output in Megawatt**
- **Atatürk Dam 2400 MW**
- Karakaya Dam 1800 MW
- Ilısu Dam 1200 MW (Under Constuction)
- Birecik Dam 852 MW

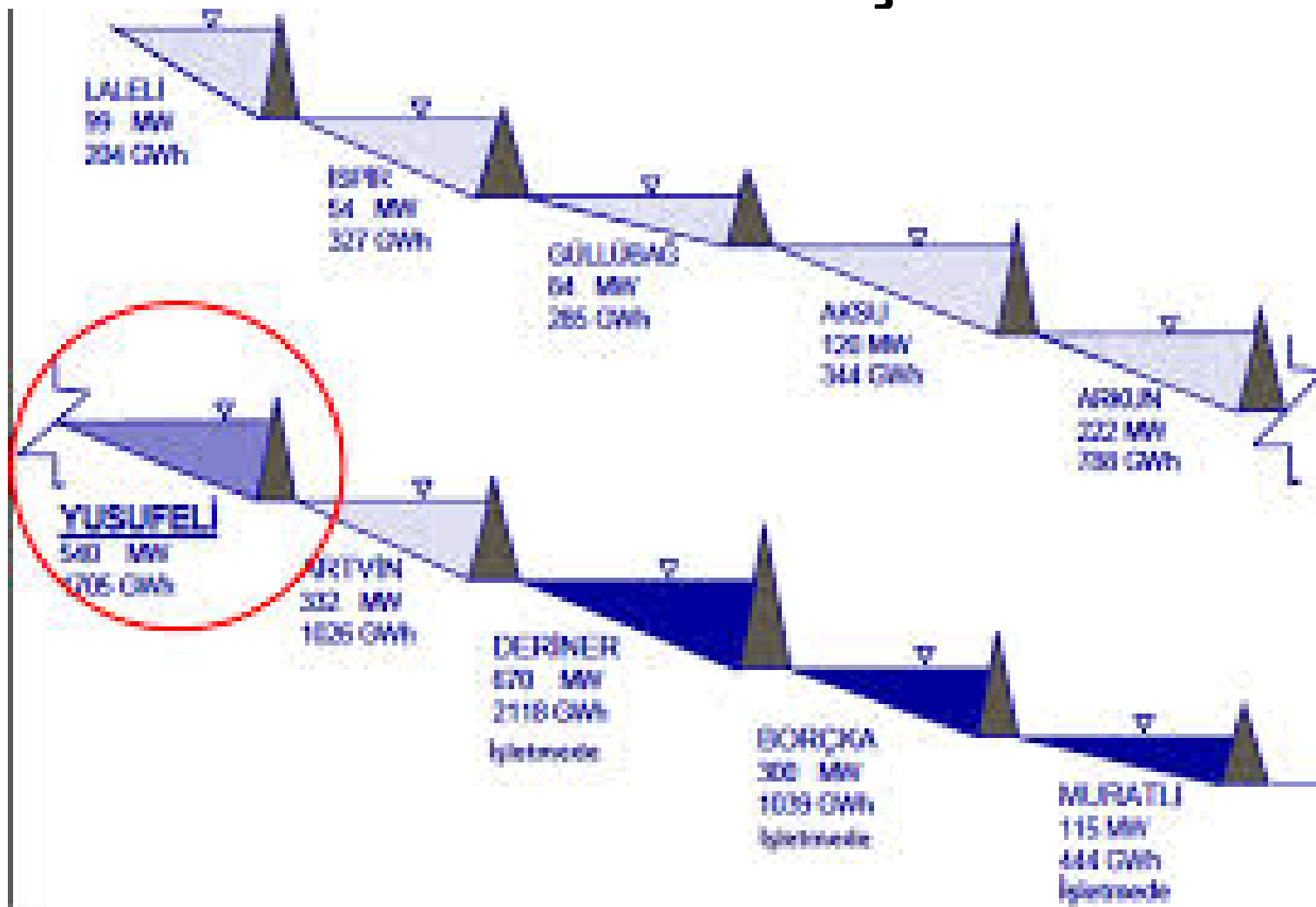
Atatürk Dam on the Euphrates River, Turkey



Under Construction

- The largest hydropower project currently under construction in Turkey is the **1200 MW Ilisu Dam**, part of the Southeastern Anatolian Project (GAP) on the Tigris.
- Similarly, **the 540 MW Yusufeli Dam** is planned to be built on the Chorakhi (Çoruh) River located in the eastern Black Sea region. It is expected to produce 1,705 GWh a year (The **highest** dam of Turkey).

Dam reservoirs on Çoruh River



ELECTRICITY DEMAND GROWTH

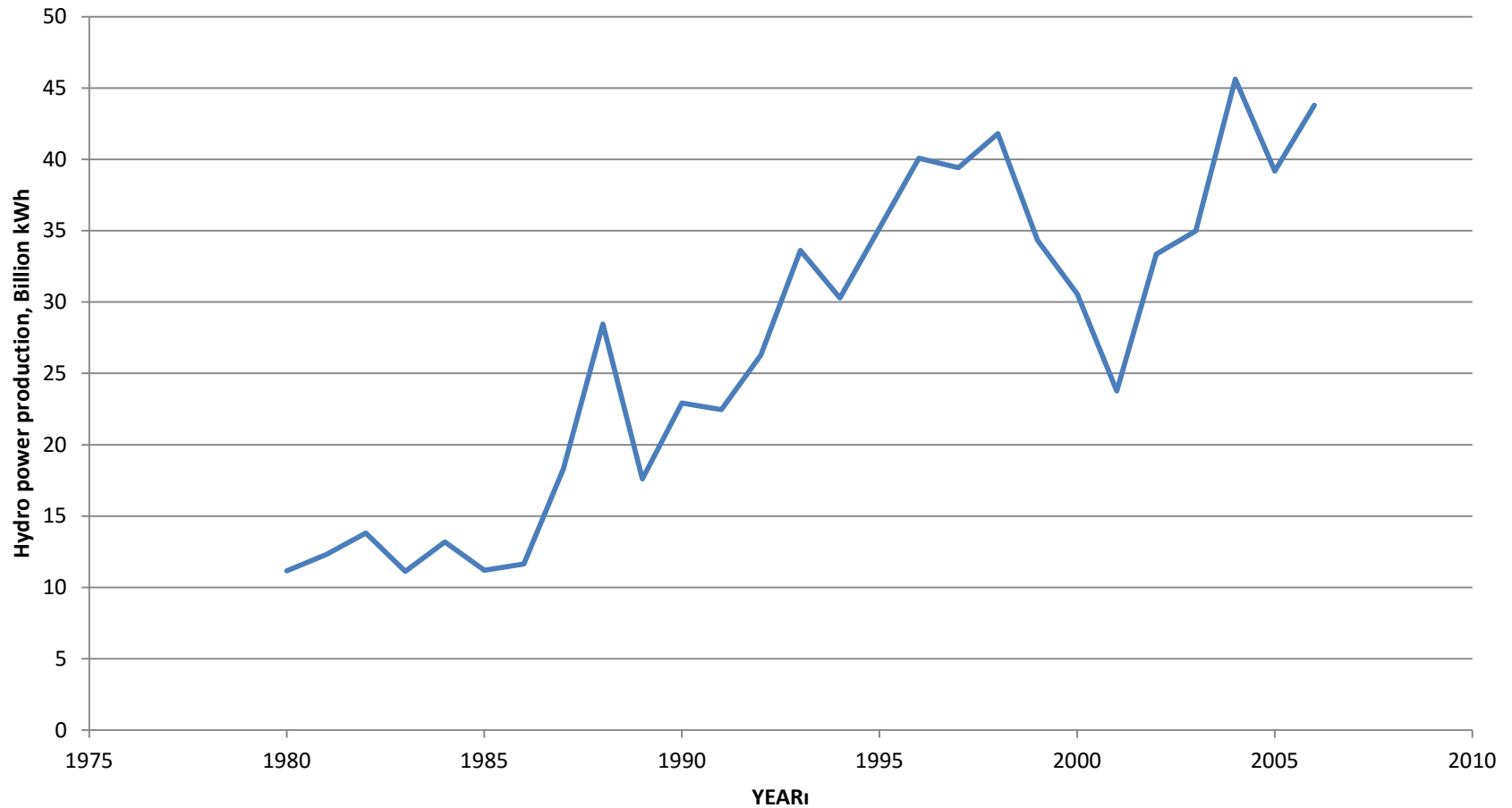
- With its high dependence on imported fuels and electricity demand growth topping 7% a year, Turkey is increasingly turning to development of its domestic resources to meet demand (average 5-7 %)

- In 2015, 25,6% of all electricity generated in the country comes from hydropower, according to data from the International Energy Agency.

- Turkey has **478 installed** hydropower plants located in provinces throughout the country, with a total installed capacity of **15.1 GW**.
- Of these, **12.6 GW** of capacity come from hydro plants and dams that impound reservoirs, and **2.5 GW are from run-of-river** projects,

- There are 534 plants currently being planned, with 160 of those under construction at around 15 GW of capacity.

Hydro Pwer Production by Year



Cost

- A primary draw for investors interested in developing Turkish hydro is **the high energy cost in the country.**
- The consumer price of electricity in domestic markets alternates between **16 and 17 US cents/kWh** (varies based on time of day), which reduces the repayment period on the investment.

Advantages

- The regional advantages, supportive political environment, and opportunities for exporting energy are all positives.
- Beyond the high power prices the region offers experienced and reputable engineering and consulting companies, with the capacity to investigate potential sites, perform feasibility studies, design infrastructure tailored to the area, prepare bidding documents and offer site supervision services.

Attractive to investors

- The low-cost labor force and large portfolio of civil and mechanical engineers working in the field of hydropower in Turkey have been **attractive to investors** and developers alike, as have the ease of communication, money transfers, and international banking systems which are in place.
- Furthermore, all the civil works construction **materials** and **goods** can be provided from within the **province** where the project is being developed or from nearby provinces, thus decreasing shipping costs during the construction phase.

Building Turkish hydropower

- An example, **Norwegian utility Statkraft** is due to complete construction on the 102 MW Kargi hydropower plant in Corum province in northern Turkey in early 2015.
- With an estimated annual average production of 467 GWh, the power plant will feature a 13 m-high earth dam.

Projection by 2020

- According to Turkish Electricity Transmission Corporation figures **electricity demand** is expected to reach around **420 TWh annually by 2020**.
- **Actually, the electricity consumption in 2015 was 264 TWh (billion kWh)**

No	Name	Capacity (MW)	River(basin)	Status
1	Atatürk	2.400	Euphrat	Operational
2	Karakaya	1.800	Euphrat	Operational
3	Keban	1.330	Euphrat	Operational
4	Ilisu	1.200	Tigris	Under Construction
5	Altinkaya	700	Kızılırmak	Operational
6	Birecik	672	Euphrat	Operational
7	Deriner	670	Çoruh	Operational
8	Oymapınar	540	Manavgat	Operational
9	Berke	516	Ceyhan	Operational
10	Boyabat	513	Kızılırmak	Operational

No	Name	Capacity (MW)	River(basin)	Status
11	Hasan-Uğurlu	500	Yeşilırmak	Operational
12	Yedigöze	317	Seyhan	Operational
13	Ermenek	306	Ermenek	Operational
14	Borçka	300	Çoruh	Operational
15	Gökçekaya	300	Sakarya	Operational
16	Sır	284	Ceyhan	Operational
17	Alkumru	265	Botan	Operational
18	Menzelet	248	Ceyhan	Operational
19	Obruk	202	Kızılırmak	Operational
20	Özlüce	200	Peri	Operational

HYDROPOWER PLANTS

- Turkey has more than 500 hydropower plants operating, generating a combined capacity of more than 15 GW and with more than 15 GW of hydropower capacity currently under construction.

Hydropower in Turkey: Analysis in the view of Vision 2023

- In 2013, more than 25.0% or 57.5 TWh of the country's electricity demand is supplied from hydropower.
- According to official projections this would increase to approximately 116.0 TWh in 2023.

- hydropower's supply rate of Turkey's annual electricity demand was assessed based on the official projections and a forecast was generated.
- Results showed that between **22.0% and 27.0%** of Turkey's annual electricity demand should be supplied from hydropower in 2023.
- Therefore, between 22.5 TWh and 45.0 TWh of electricity should be generated from renewable energy sources other than hydropower to provide a total of **30.0% renewable energy based** electricity generation in 2023.

Turkey to privatize 10 hydropower plants (*January 11 2016*)

- Turkey's Privatization Administration (ÖİB) has opened tenders for the privatization of a total of **10 hydropower plants**, the Official Gazette said on July 29.
The power plants will be privatized in different groups.

PRIVATISATION in OPERATION

- The bid security for the first group of power plants, **Karacaören 1 and 2**, was set at 25 million Turkish Liras;
- for the second group, **Kepez 2 and Manavgat**, at 20 million liras;
- for the third group, **Fethiye**, at 10 million liras;
- for the fourth group, **Kadıncık 1 and 2**, at 30 million liras;
- and for the fifth group, **Doğakent, Kürtün and Torul**, at 50 million liras.

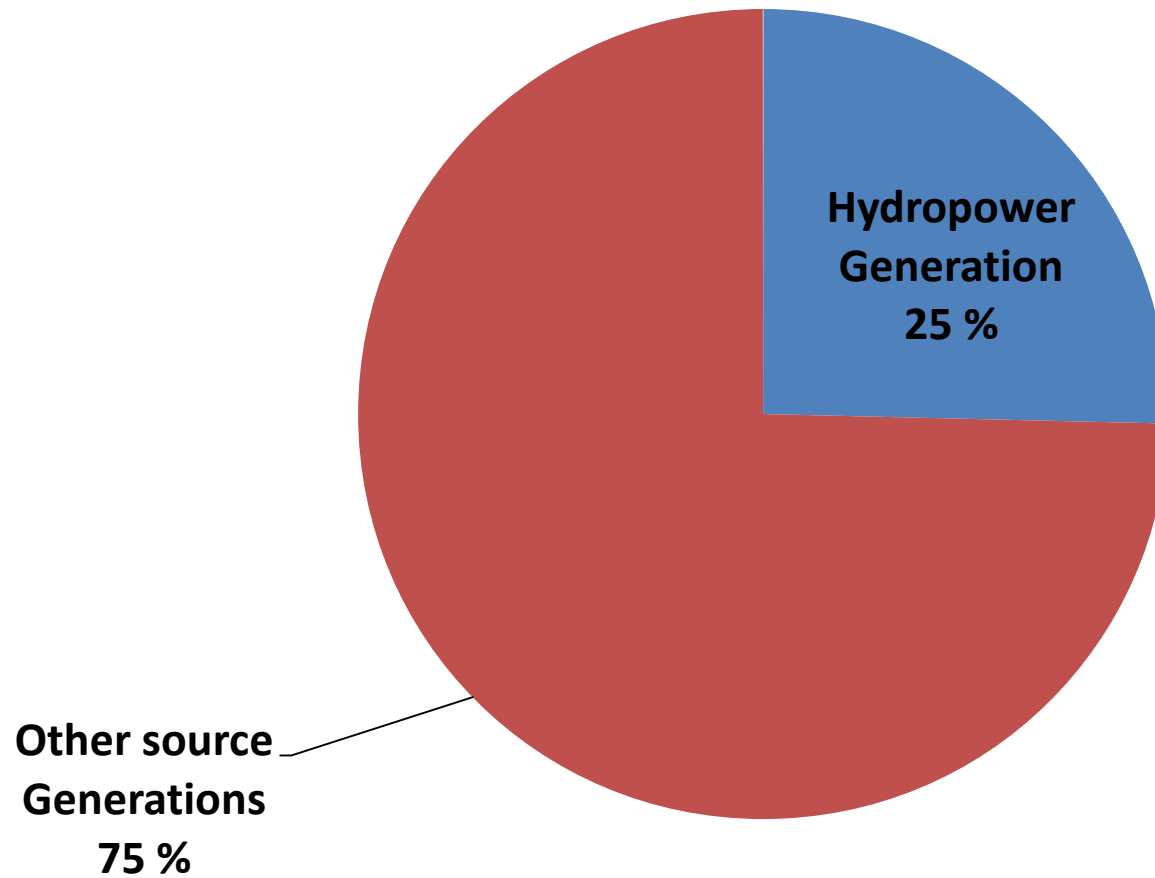
The bids will be submitted until Oct. 27 for the first group, Oct. 14 for the second group, Oct. 5 for the third group, Nov. 10 for the fourth group, and Nov. 20 for the fifth group.

LAW

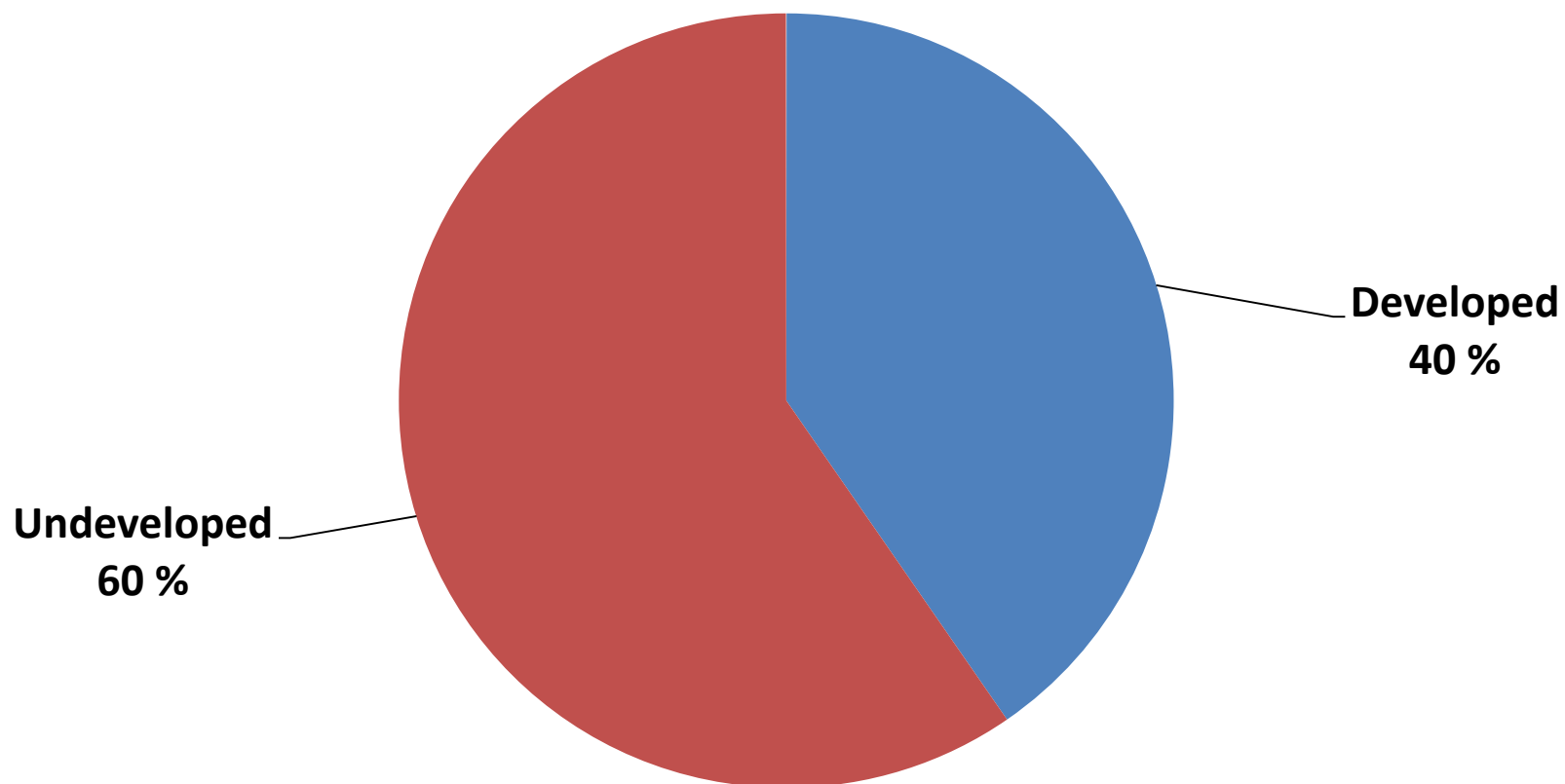
- **LAW ON UTILIZATION OF RENEWABLE ENERGY SOURCES FOR THE**
 - **PURPOSE OF GENERATING ELECTRICAL ENERGY**

- **Law No.: 5346** : **5346**
- **Adoption date** : **10/5/2005**
- **Published in the Official Gazette** : **No. 25819** dated **18/5/2005**

ELECTRICITY PRODUCTION OF TURKEY, 2015 (264 billion kWh)



HYDROPOWER POTENTIAL OF TURKEY, 2015 (166 Billion kWh)



Appendix

1. List of countries by electricity production

Rank	Country/Region	Electricity production (GWh)	Date of information
N/A	<i>World Total</i>	23,536,500	2014 ^{[1][2]}
1	China	5,649,500	2014 ^[1]
2	United States	4,297,300	2014 ^[1]
N/A	European Union	3,166,000	2014 ^[1]
3	India	1,208,400	2014 ^[1]
4	Russia	1,064,100	2014 ^[1]
5	Japan	1,061,200	2014 ^[1]
6	Canada	615,400	2014 ^[1]
7	Germany	614,000	2014 ^[1]
8	Brazil	582,600	2014 ^[1]
9	France	555,700	2014 ^[1]
10	South Korea	517,800	2014 ^[1]

Rank	Country/Region	Electricity production (GWh)	Date of information
11	United Kingdom	356,800	2013 ^[2]
12	Mexico	293,600	2013 ^[2]
13	Saudi Arabia	292,200	2013 ^[2]
14	Italy	288,400	2013 ^[2]
15	Spain	285,300	2013 ^[2]
16	Iran	263,400	2013 ^[2]
17	South Africa	256,100	2013 ^[2]
18	Taiwan	252,000	2013 ^[2]
19	Australia	244,800	2013 ^[2]
20	Turkey	239,300	2013 ^[2]
21	Indonesia	216,200	2013 ^[2]
22	Ukraine	193,800	2013 ^[2]
23	Thailand	164,800	2013 ^[2]
24	Poland	164,400	2013 ^[2]
25	Sweden	160,400	2013 ^[2]

2. Production and source (2011)

Country	Electricity production (TWh)	% Coal	% Natural gas	% Oil	% Hydropower	% Other renewable	% Nuclear power
Argentina	129.6	2.5	51.4	15.1	24.4	1.7	4.9
Australia	252.6	68.6	19.7	1.6	6.6	3.5	0
Austria	62.2	11.8	19.9	1.6	55	10.7	0
Canada	636.9	12	9.8	1	59	3.3	14.7
Chile	65.7	29.9	20.9	9.7	32	7.6	0
China	4,715.7	79	1.8	0.2	14.8	2.2	1.8

Country	Electricity production (TWh)	% Coal	% Natural gas	% Oil	% Hydropower	% Other renewable	% Nuclear power
Denmark	35.2	39.7	16.5	1.3	0	40.2	0
Egypt	156.6	0	74.7	15.8	8.3	1.3	0
Finland	73.5	14	12.9	0.6	16.9	15.9	31.6
France	556.9	3.1	4.8	0.6	8	3.6	79.4
Germany	602.4	45.1	13.9	1.1	2.9	17.6	17.9
India	1,052.3	67.9	10.3	1.2	12.4	5	3.2
Indonesia	182.4	44.4	20.3	23.2	6.8	5.2	0

Country	Electricity production (TWh)	% Coal	% Natural gas	% Oil	% Hydropower	% Other renewable	% Nuclear power
Iran	239.7	0.2	66.8	27.8	5	0.1	0.1
Iraq	54.2	0	62.1	12.9	7.6	0	0
Israel	59.6	59	33.1	7.3	0	0.4	0
Italy	300.6	16.7	48.1	6.6	15.2	12.4	0
Japan	1,042.7	27	35.9	10.1	8	4.2	9.8
Kuwait	57.5	0	38	62	0	0	0

Country	Electricity production (TWh)	% Coal	% Natural gas	% Oil	% Hydropower	% Other renewable	% Nuclear power
Libya	27.6	0	56.3	43.7	0	0	0
Malaysia	130.1	40.7	44.7	7.7	5.9	1	0
Mexico	295.8	11.5	52.8	16.4	12.3	3.6	3.4
Mongolia	4.8	95.1	0	4.9	0	0	0
Netherlands	113	21.9	60.6	1.3	0.1	10.9	3.7
New Zealand	44.5	4.9	19.1	0	56.4	19.5	0

Country	Electricity production (TWh)	% Coal	% Natural gas	% Oil	% Hydropower	% Other renewable	% Nuclear power
Sudan	8.6	0	0	24.8	75.2	0	0
Sweden	150.3	0.9	1	0.5	44.2	11.7	40.2
Syria	41.1	0	52.4	39.6	8	0	0
Turkey	229.4	28.9	45.4	0.4	22.8	2.5	0
United Kingdom	364.9	30	40.2	1	1.6	7.9	18.9
United States	4,326.6	43.3	24.2	0.9	7.4	4.8	19
World	22,158.5	41.2	21.9	3.9	15.6	4.2	11.7

Country	Electricity production (TWh)	% Coal	% Natural gas	% Oil	% Hydropower	% Other renewable	% Nuclear power
<u>Pakistan</u>	95.3	0.1	29	35.4	29.9	0	5.5
<u>Philippines</u>	69.2	36.6	29.8	4.9	14	14.6	0
<u>Poland</u>	163.1	86.7	3.6	1.5	1.4	6.6	0
<u>Russia</u>	1,053	15.5	49.3	2.6	15.7	0.1	16.4
<u>Saudi Arabia</u>	250.1	0	43.3	26.5	0	0	0
<u>South Africa</u>	259.6	93.8	0	0.1	0.8	0.2	5.2
<u>South Korea</u>	520.1	43.2	22.3	3.2	0.9	0.6	29.8
<u>Spain</u>	289	15.5	29.2	5.1	10.6	19.2	20

- Thank You