

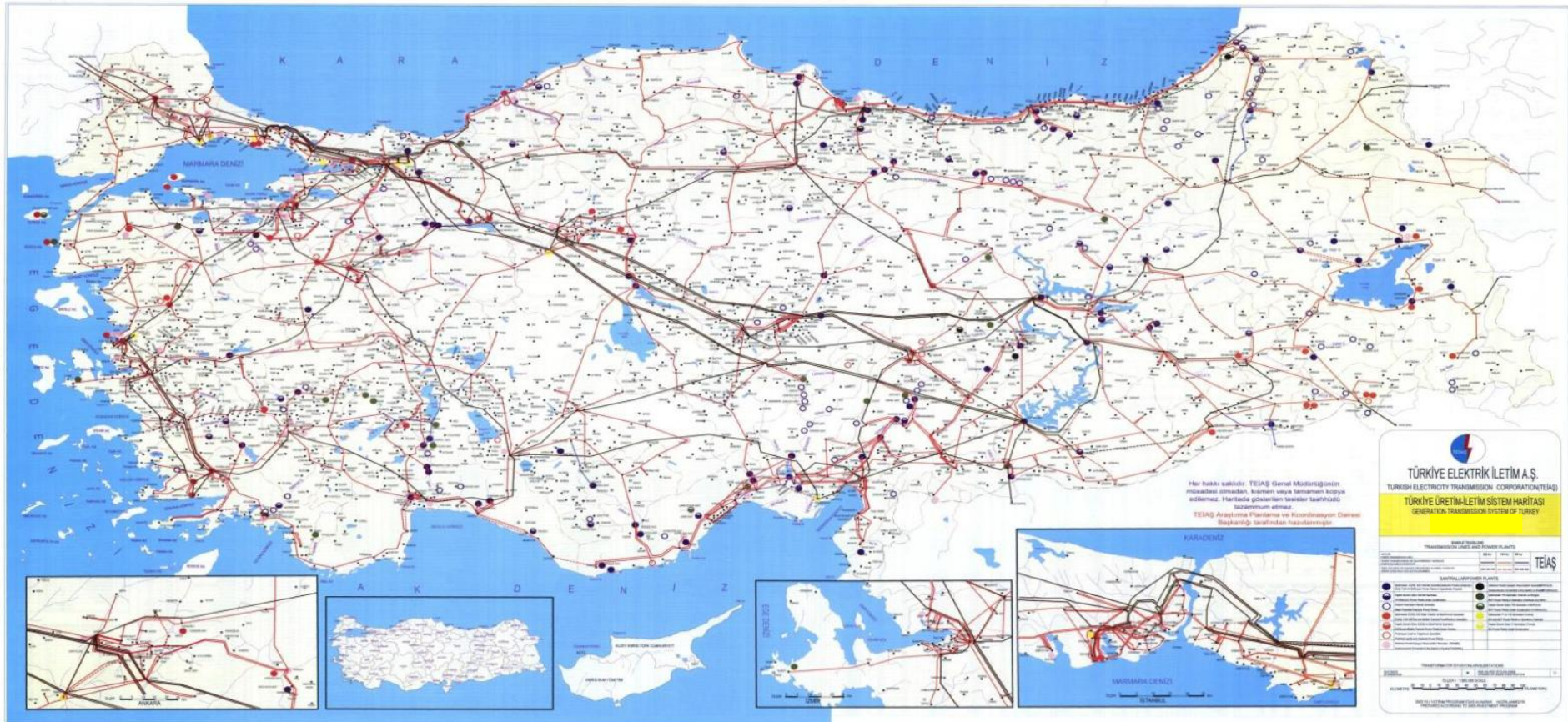
# **TURKISH POWER SYSTEM and WIND POWER CONNECTION**

**Yusuf BAYRAK**  
**Turkish Electricity Transmission Corporation**  
**TEİAŞ**

# TEİAŞ MAIN RESPONSIBILITIES

- The sole owner of Electricity Transmission System
- Responsible for the expansion of transmission network infrastructure, construction of new transmission facilities
- Operating & Maintaining the Turkish Electricity Transmission Network economically and reliably in compliance with international standards
- Monitoring real-time system reliability, purchasing and providing Ancillary Services through **“Ancillary Service Agreements”**
- Publishing 10-year **“Electrical Energy Generation Capacity Projection”**
- Preparing Long-Term (20 years) **“Electricity Generation Expansion Planning”**
- Operating the Electricity Balancing Market and Financial Reconciliation Center (PMUM)
- Carrying out studies for the Interconnection Lines with neighbouring countries

# TURKISH POWER SYSTEM



## NUMBER OF SUBSTATIONS

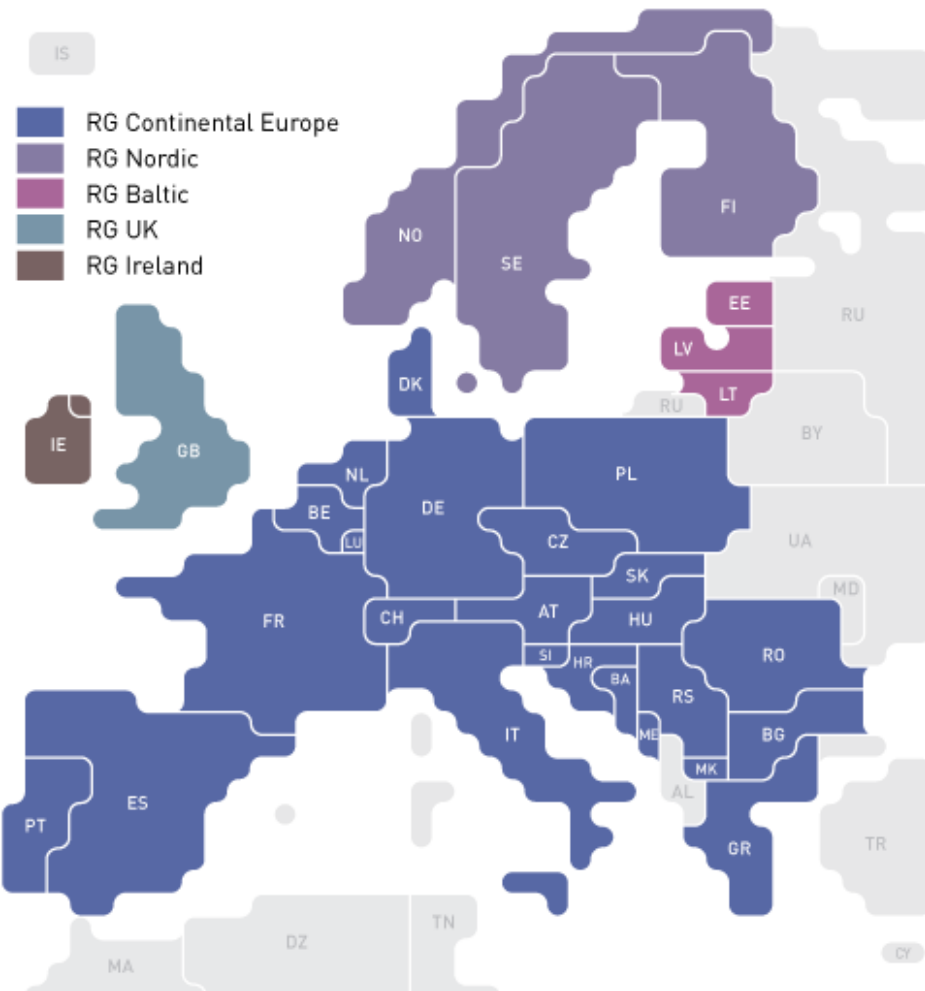
- 400 kV      81
- 220 kV      1
- 154 kV      537
- 66 kV       13

**TOTAL: 632 (108.378 MVA TOTAL TRANSFORMER INSTALLED CAPACITY)**

## LENGTH OF TRANSMISSION LINES

- 400 kV      16324 km
- 154 kV      33203 km
- 220 kV      85 km
- 66 kV       508 km
- 154 kV & 400 kV Cable Length      220 km
- TOTAL      50.340 km

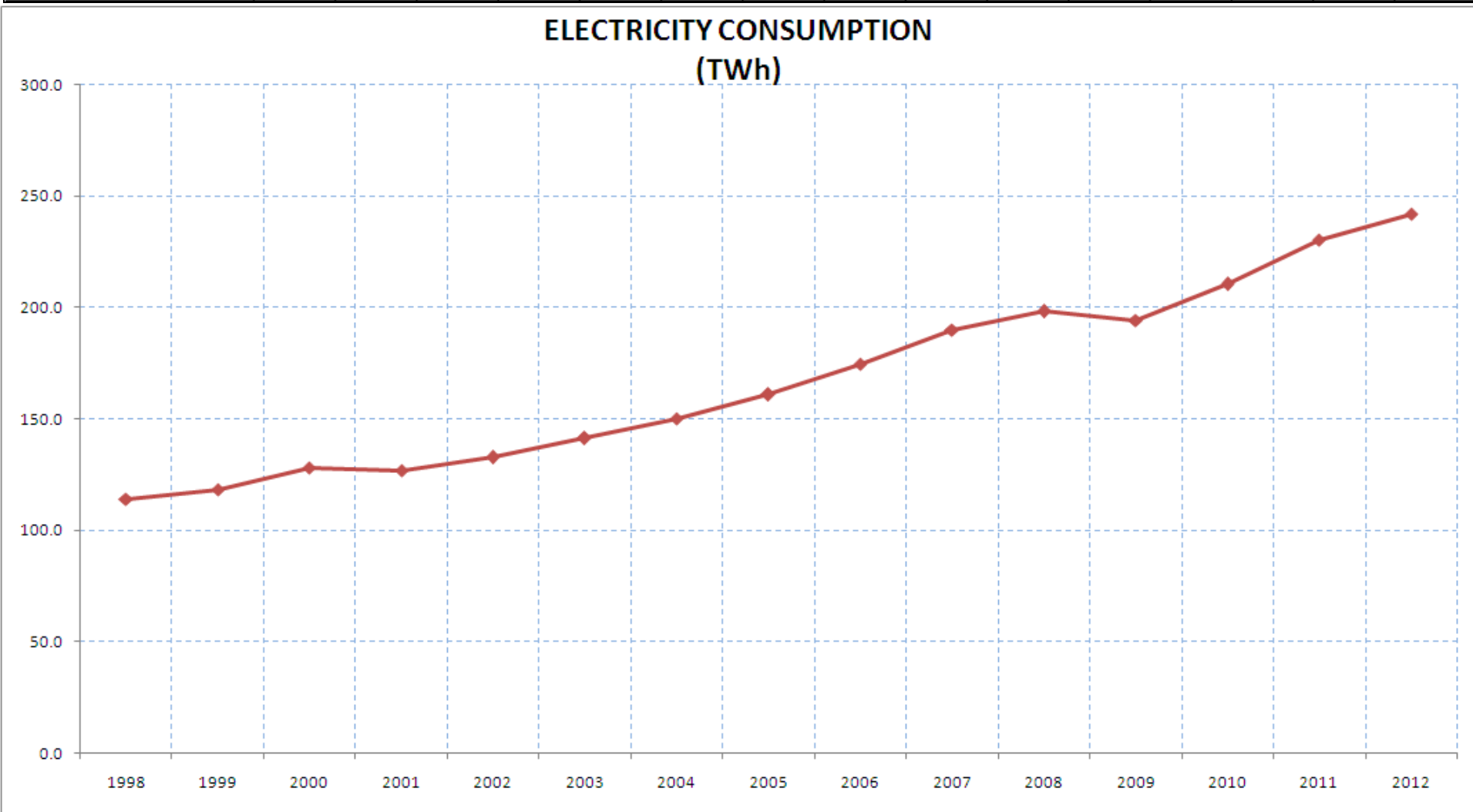
# ENTSO-E (UCTE) CONNECTION



- Trial Run period started with ENTSO-E on 18<sup>th</sup> of September 2010.
- The **first phase** system stability tests approved by ENTSO-E Planary Group on 8<sup>th</sup> of February.
- Without any trade Import-Export tests for the **second phase** found successfull by ENTSO-E.
- The **third phase** (import-export with trade) related with the synchronous parallel operation of Turkey with European Power System started on 1<sup>th</sup> of June 2011 and technical evaluation of the trial period was extended to Autumn of 2013 which previously had been extended to 18 September 2012 .

# TOTAL ELECTRICITY CONSUMPTION

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
CONSUMPTION(TWh)	114.0	118.5	128.3	126.9	132.6	141.2	150.0	160.8	174.6	190.0	198.1	194.1	210.4	230.3	241.9
INCREASE(%)	8.1	3.9	8.3	-1.1	4.5	6.5	6.3	7.2	8.6	8.8	4.3	-2.0	8.4	9.4	5.0



# TOTAL INSTALLED CAPACITY AND PEAK LOAD

**2011**

Installed Capacity: 52.911,1 MW

Consumption: 230,3 TWh

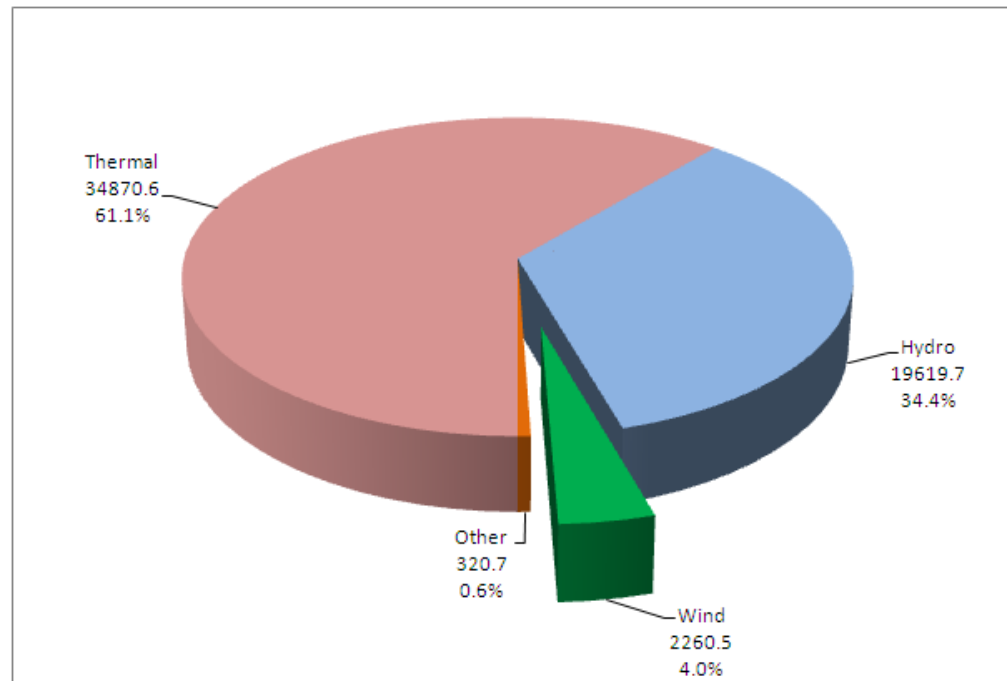
Peak Load: 36.122,4 MW

**2012**

Installed Capacity: 57.071 MW

Consumption: 241,9 TWh

Peak Load: 39.045 MW  
(27.07.2012 14:30)



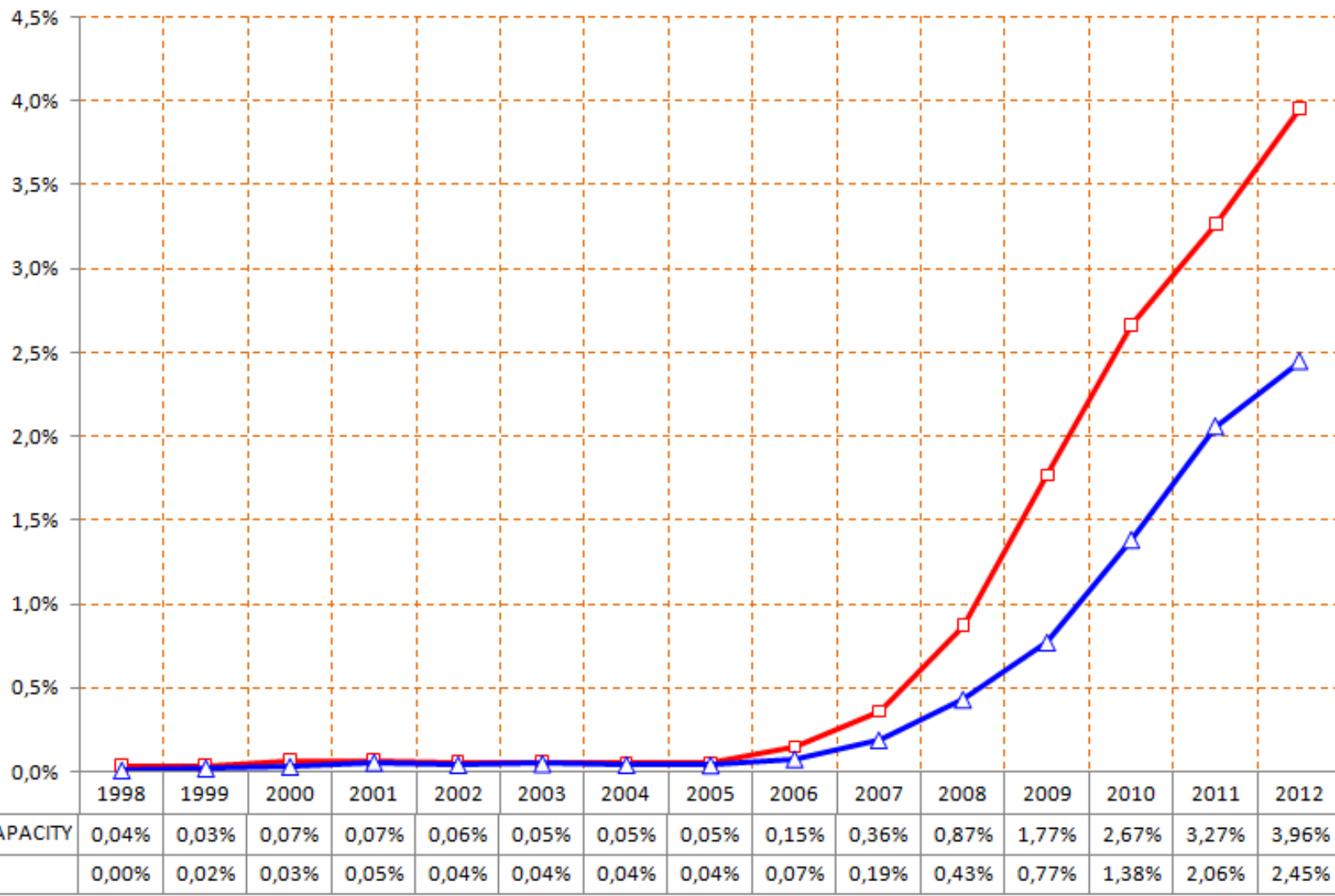


# EXISTING and PLANNED WPP's



\*Red markers indicate WPP in operation, blue markers indicate WPP in planning phase.

# WIND POWER SHARE IN TOTAL INSTALLED CAPACITY





# NEW APPLICATIONS TO CONNECT TO THE GRID

POWER PLANTS CONNECTION APPLICATION	HYDRO	WIND	THERMAL		TOTAL
			NGCC	OTHER	
CONNECTION HAS BEEN APPROVED BY TEİAŞ	5924	1880	25457	14121	47382
CAPACITY HAS BEEN LICENCED BY EMRA	9390	5093	5753	3907	24143
CAPACITY HAS BEEN SIGNED CONNECTION AGREEMENT BY TEİAŞ	6778	2083	6672	4966	20499
<b>TOTAL</b>	<b>22092</b>	<b>9056</b>	<b>37882</b>	<b>22994</b>	<b>92024</b>

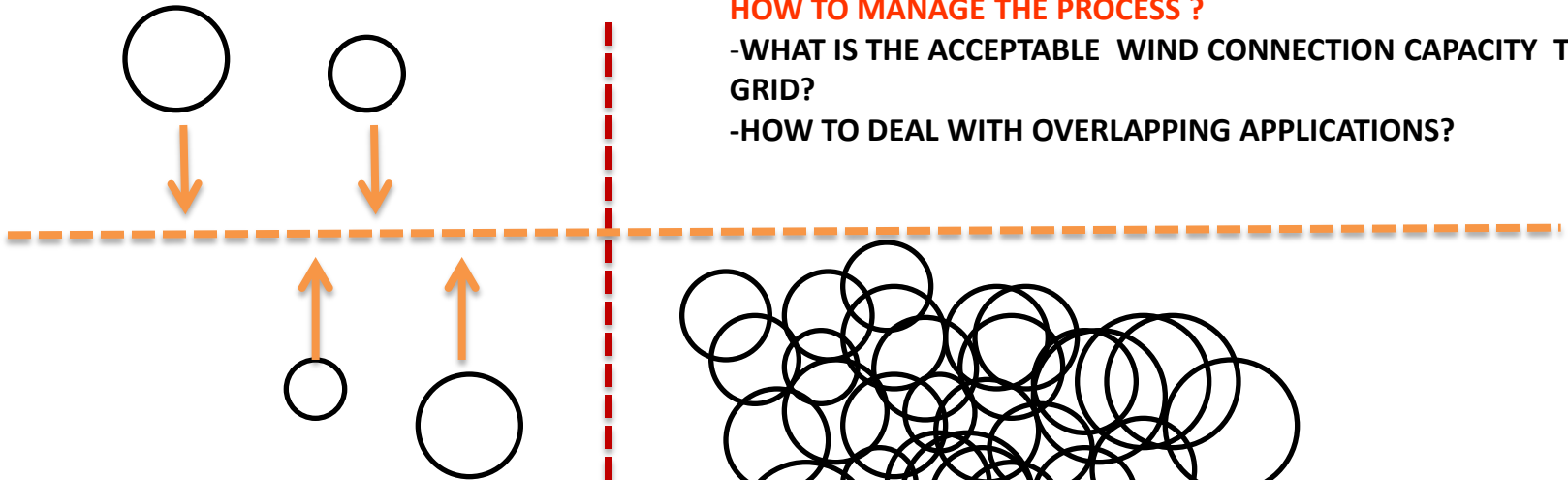
According to “Turkish Electricity Capacity Projection Study” prepared by TEİAŞ and approved by EMRA, there are uncertainties on capacities already applied to be connected to Grid.

YILLAR	2013	2014	2015	2016	2017	2018	2019	2020	2021	Uncertain
THERMAL	277.3	1635.2	3993.0	1225.0						8993.2
NUCLEAR							1200.0	1200.0	1200.0	0.0
HYDRO	990.5	2830.5	3711.7	3603.3	1788.0	420.6				431.4
GEOTHERMAL	34.0	48.5								141.5
WIND	284.3	481.4								3573.4
TOPLAM	1586.1	4995.6	7704.7	4828.3	1788.0	420.6	1200.0	1200.0	1200.0	13139.5

# A BRIEF HISTORY of WPP INTEGRATION

First WPP  
commissioned in 1998

1 NOVEMBER  
2007



**HOW TO MANAGE THE PROCESS ?**

- WHAT IS THE ACCEPTABLE WIND CONNECTION CAPACITY TO GRID?
- HOW TO DEAL WITH OVERLAPPING APPLICATIONS?

SINGULAR WPP APPLICATIONS  
AND LICENCED SEPERATELY

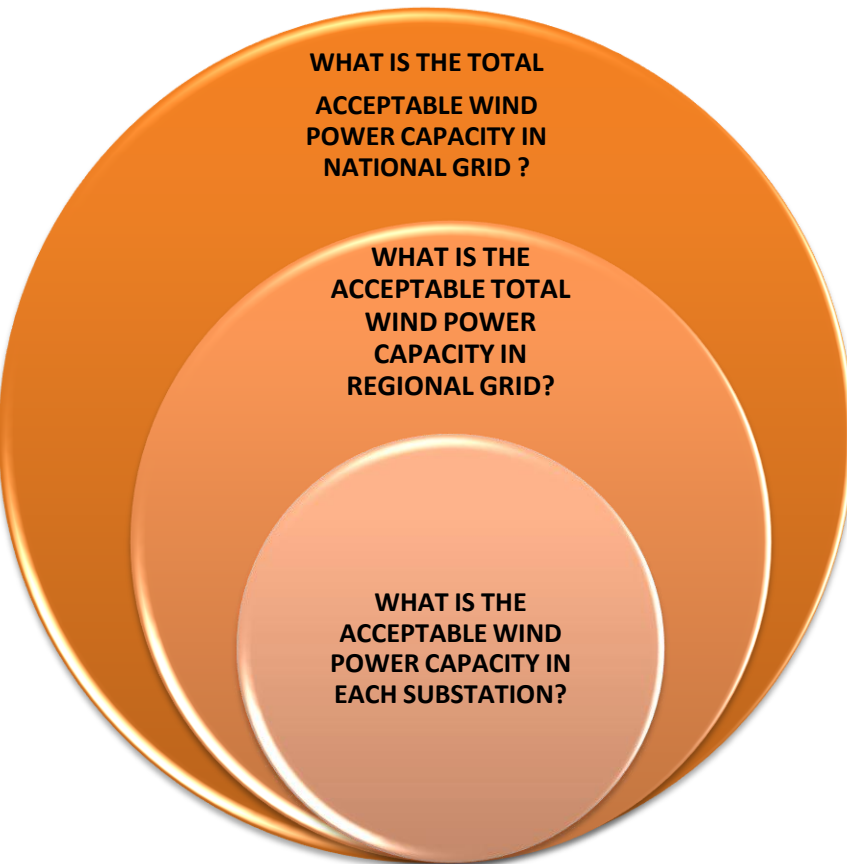
**3500MW** OF WIND CAPACITY WAS  
ALLOCATED BEFORE 1 NOV. 2007

Application of the 722 Wind PP's  
Total capacity of applications: 78.000 MW

Most applications are overlapping  
or have applied for the same geographical area

# WPP INTEGRATION PROCESS TO THE GRID

## LIMITING FACTORS FOR ACCEPTABLE WIND POWER CAPACITY IN THE GRID



THE FACTORS THAT LIMIT THE ACCEPTABLE WIND POWER CAPACITY CONNECTION TO THE NATIONAL GRID

- GENERATION- CONSUMPTION BALANCE
- FREQUENCY RESERVES

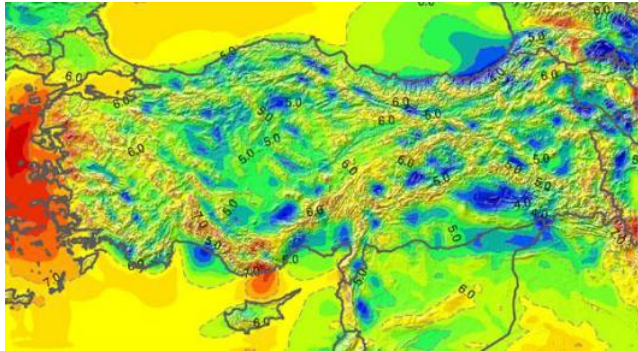
THE FACTORS THAT LIMIT THE ACCEPTABLE WIND POWER CAPACITY CONNECTION TO THE REGIONAL GRID

- VARIATIONS OF POWER FLOW
- REGIONAL ENERGY QUALITY
- ADDITIONAL INVESTMENTS(New Lines,Substations,Etc.)

FACTORS THAT LIMIT THE ACCEPTABLE WIND POWER CAPACITY CONNECTION TO SUBSTATIONS

- ENERGY QUALITY
- SHORT CIRCUIT POWER ON MEDIUM VOLTAGE LEVEL

# WPP INTEGRATION PROCESS



APPLICATION 78.000 MW

NATIONAL-REGIONAL  
AND SUBSTATION  
LEVELS OF ACCEPTABLE  
WIND POWER  
CAPACITIES WERE  
DETERMINED AND  
PUBLISHED

ALL APPLICATIONS  
WERE DIRECTED TO THE  
NEAREST SUBSTATION

IF THERE HAD BEEN ONLY ONE  
APPLICATION IN THE  
SUBSTATION , IT WAS LICENCED  
IMMEDIATELY.

IF THERE HAD BEEN MORE THAN  
ONE APPLICATION IN THE  
SUBSTATION , COMPETITION  
TOOK PLACE AMONG THEM.

SINGLE APPLICATIONS  
LICENCED 2057 MW

APPLICATIONS  
LICENCED ACCORDING  
TO COMPETITION  
RESULTS 5499 MW

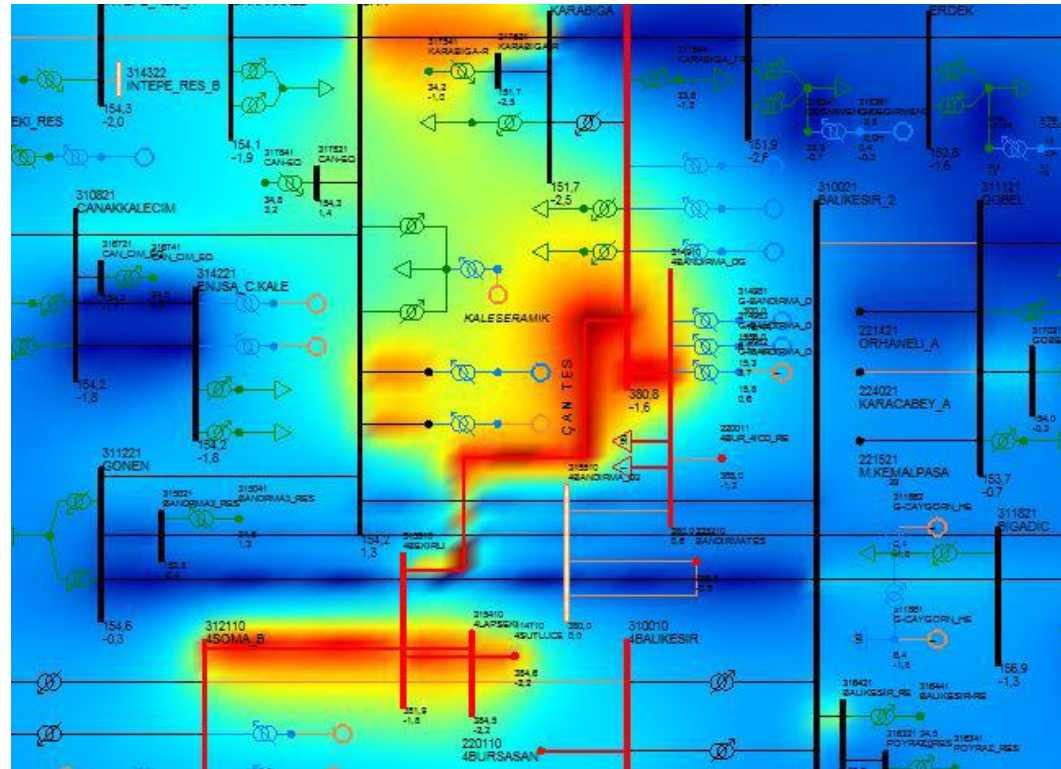
PROCESS

TOTAL CAPACITY ALLOCATED UNTIL THE END OF 2013 IS **~12000 MW**  
TURKEY AIMS TO INTEGRATE **20.000 MW** OF INSTALLED WIND  
POWER UNTIL 2023.

# WPP INTEGRATION PROCESS TO THE GRID

## DETERMINATION OF CONNECTABLE WIND POWER CAPACITY TO THE SYSTEM

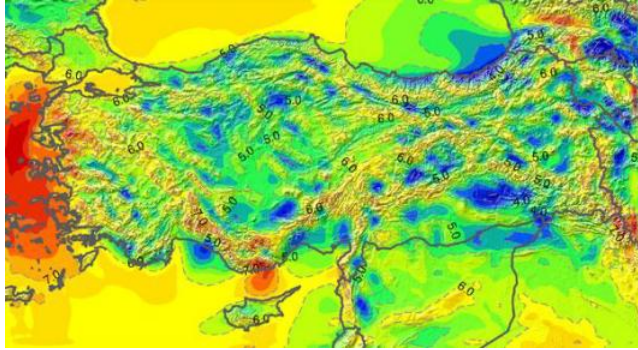
- Evaluation of the available wind power capacity can be connected to the system
- Power Flow studies
- Evaluation of wind variability on the effect of power flow and local grid
- Planning the investment of basin substation and transmission lines





# WPP INTEGRATION PROCESS TO THE GRID

DETERMINATION OF TOTAL AVAILABLE WIND POWER CAPACITY TO BE CONNECTED TO THE GRID



APPLICATIONS: 78.000 MW

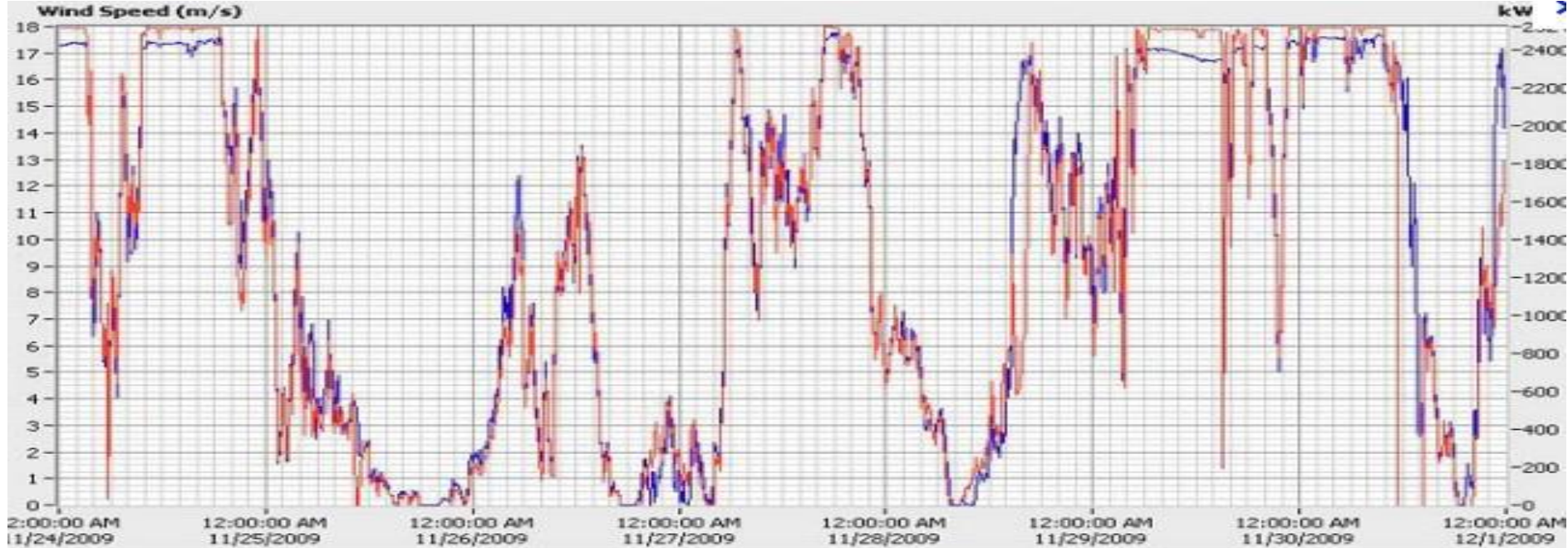
## APPLIED APPROACHES IN THE WORLD

- ❖ Integration to the 1/3 ratio to the demand of system minimum load
- ❖ Integration to the 25% ratio to the demand of system maximum load

2013 Estimated Minimum System Load		2013 Estimated Maximum System Load (Peak)	
	18.703 MW		46.757 MW
(1/3 of Peak )	6.727 MW	(25% of Peak)	11.689 MW

# WPP INTEGRATION PROCESS TO THE GRID

## DETERMINATION OF CONNECTABLE WIND POWER CAPACITY TO THE SYSTEM



Typical Wind Generation Record

### NEGATIVE EFFECTS OF WIND POWERPLANTS ON GRID

- **FAULT-RIDE TROUGH CAPABILITY OF WPP'S**
- **FLICKER** (Turbulence/Output Power Source)
- **VOLTAGE FLUCTUATION** (Cause of Output Power fluctuation and insufficient of reactive power support)
- **HARMONICS** (Cause of Power Electronic Equipments)

# WPP INTEGRATION PROCESS TO THE GRID

## WIND POWER CAPACITY CAN BE CONNECTED TO BUSBARS

According to new regulation published in January 2013, **IEC 61400** standards are applied to determine available wind power capacity that can be connected to busbar.

## EXISTING WIND POWER PLANTS

**According to "*Licensing Regulation*", the existing power plants can apply for increasing the WPP capacity within the licensed area and without any need for modernization and renovation investments with the existing Transmission or Distribution Line.**

## WPP WITHOUT LICENCE

**According to regulation published by Energy Market Regulatory Authority (EMRA), dated 03<sup>th</sup> December 2010 legal and natural personalities get right to construct cogeneration systems and renewable capacity not exceeding 500 kW without getting licence.**

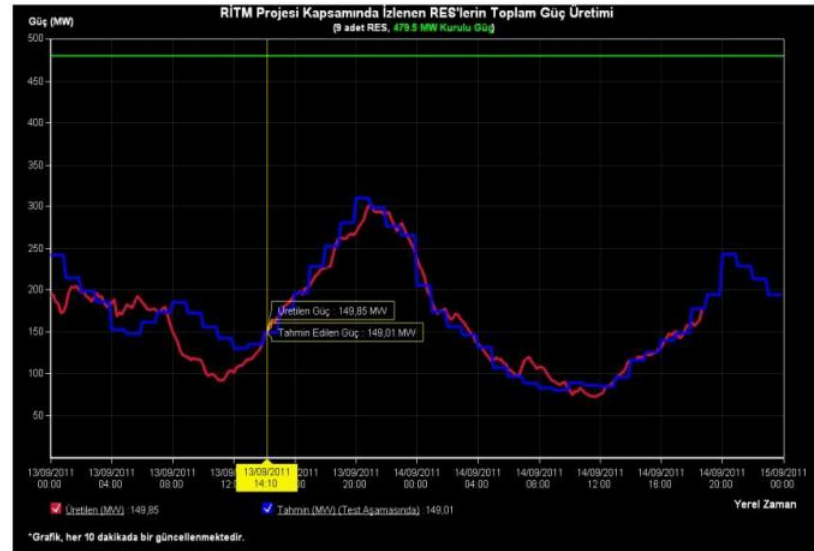
**For this purpose, TEİAŞ allocated 2 MW for wind and solar power plants, and 1 MW for cogeneration for each substation. Distribution companies will not ask TEİAŞ for permission for connection of this plants until the total application reaches to the allocated capacity.**

**However, if this allocated amount is exceeded, TEİAŞ will be asked to re-vision for capacity increase and TEİAS will make a new assessment of the particular substation.**



# MONITORING OF WIND POWER PLANTS

All Licensed wind power plants have to establish the necessary infrastructure to provide the monitoring of the wind park from **Wind Power Monitoring and Forecast Center (RİTM)**, developed by General Directorate of Renewable Energy. WPP's will be monitored also from TEİAŞ Dispatch Centers for wind forecast.



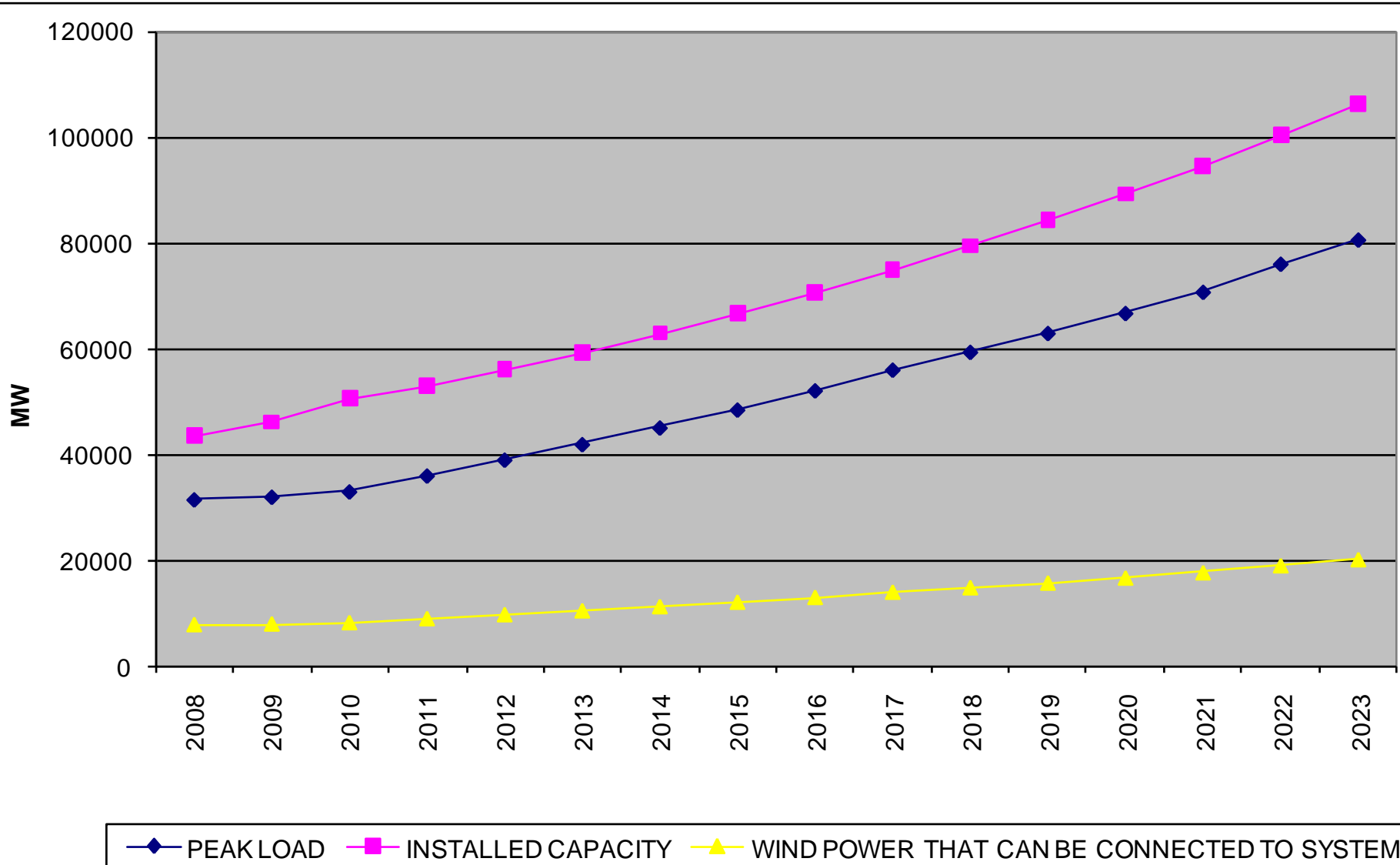
\*Grafik, her 10 dakikada bir güncellenmektedir.

# INCENTIVES FOR RENEWABLE POWER PLANTS

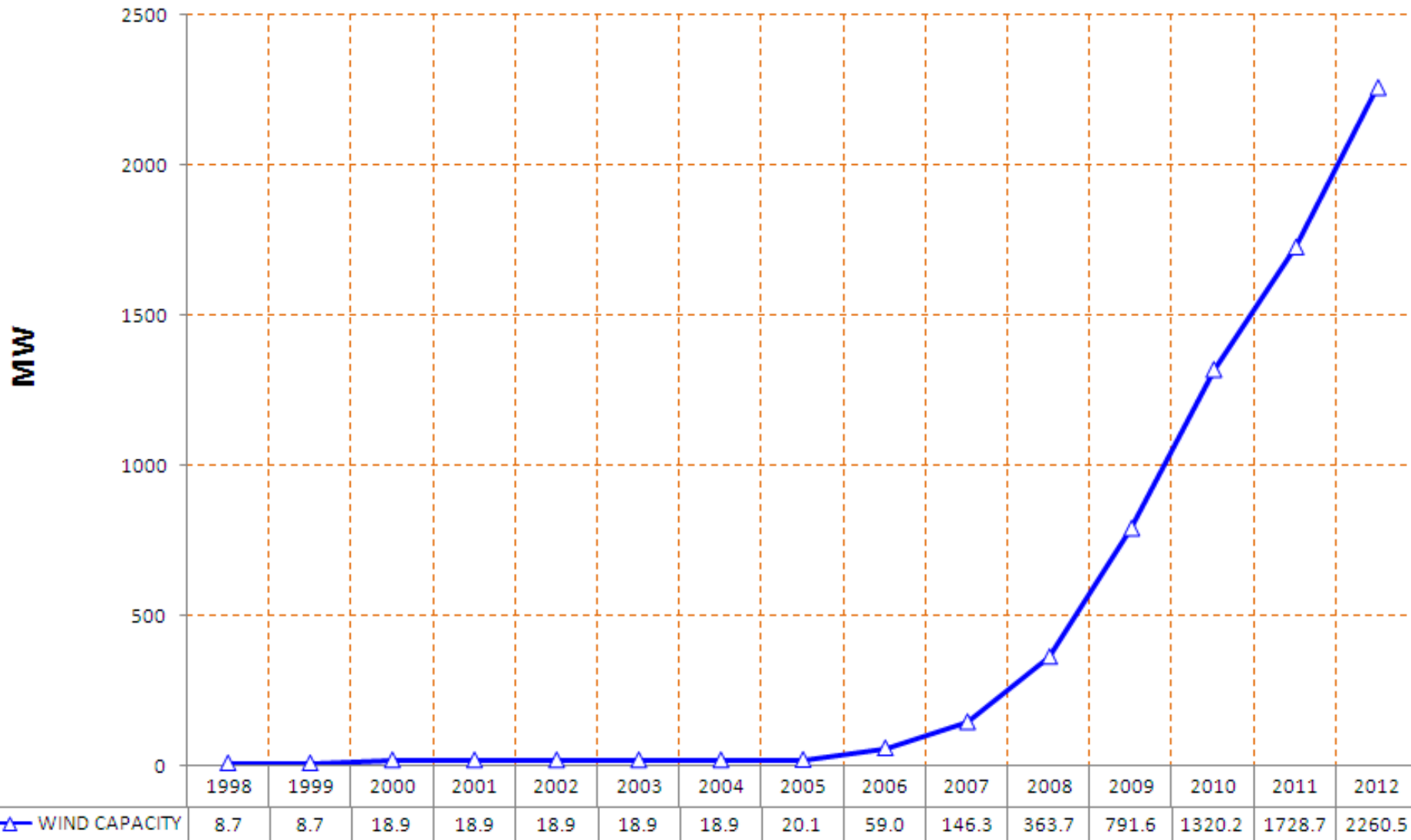
**The Parliament approved a Law on 29 December 2010, on regulating the Renewable Energy Resources in Turkey. The incentives to be applied for Renewable Power Plants:**

- **Purchasing is guaranteed to electricity to companies founded between May 13, 2005 and December 31, 2015 if they accept to have Renewable Energy Document.**
  - **7.3 U.S. cents/kWh for wind and hydro**
  - **10.5 US cents/kWh for geothermal**
  - **13.3 US cents/kWh for solar and waste**
- **For companies founded later than Dec. 31, 2015, new prices will be determined by the Government. According to the Law, the prices for the new companies will not exceed the current figures, the law said.**
- **If operators use local equipment and technology in renewables energy facilities, an additional support of 0.4 cents to 2.4 \$ per kW will be provided for five year term to companies that started producing energy before the end of 2015.**
- **The surplus generation from the renewables without Licence (Maximum Capacity is 500 kW) will be bought by the distribution companies for ten years guarantee with the defined energy prices.**
- **The law limits the total production of licensed solar energy with 600 MW until the year of 31 December 2013 and authorizes the Government to determine the limits afterwards.**

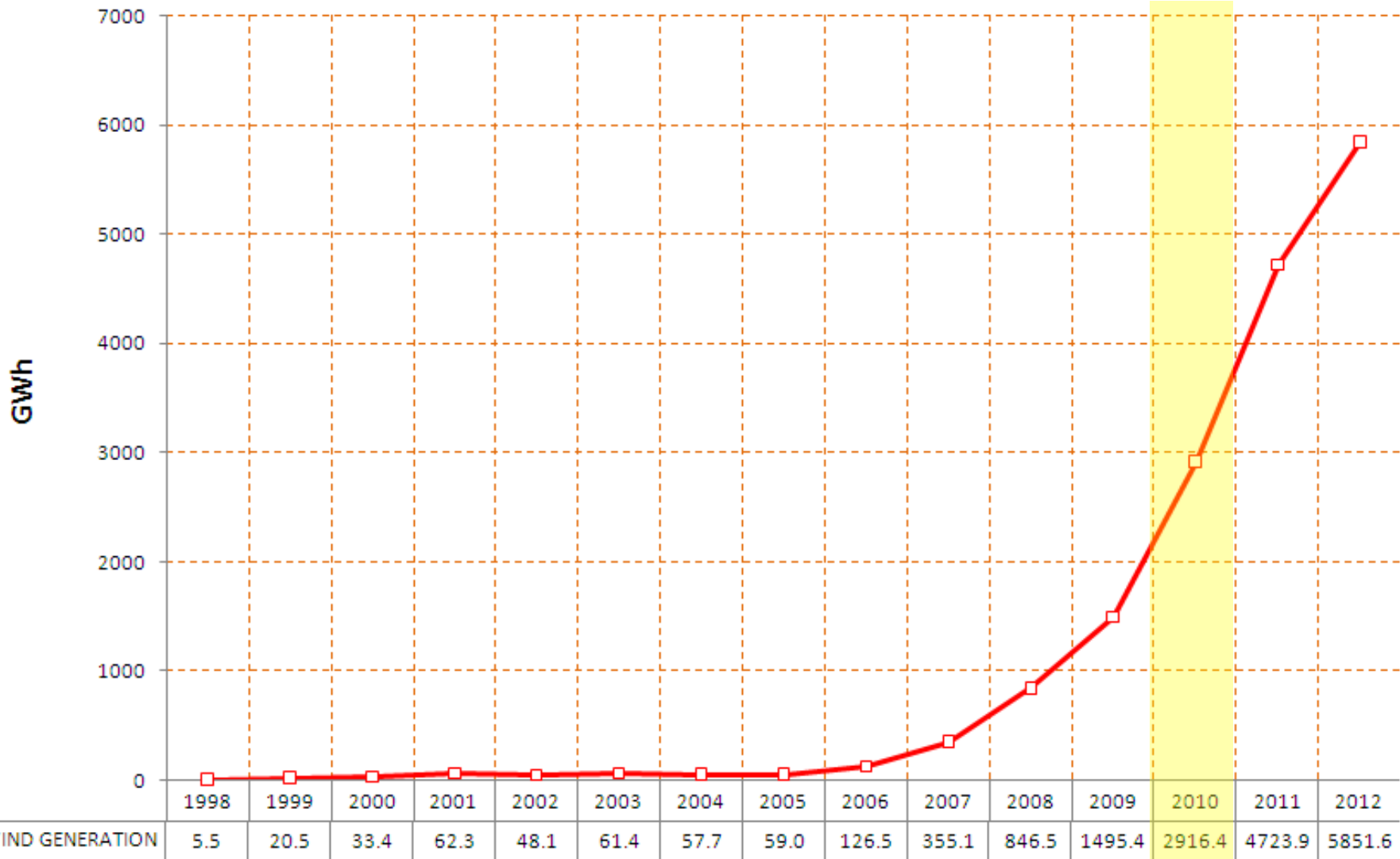
# INSTALLED CAPACITY AND PEAK LOAD PROJECTIONS & WIND POWER CONNECTION AVAILABILITY TO SYSTEM



# DEVELOPMENT OF WIND INSTALLED CAPACITY

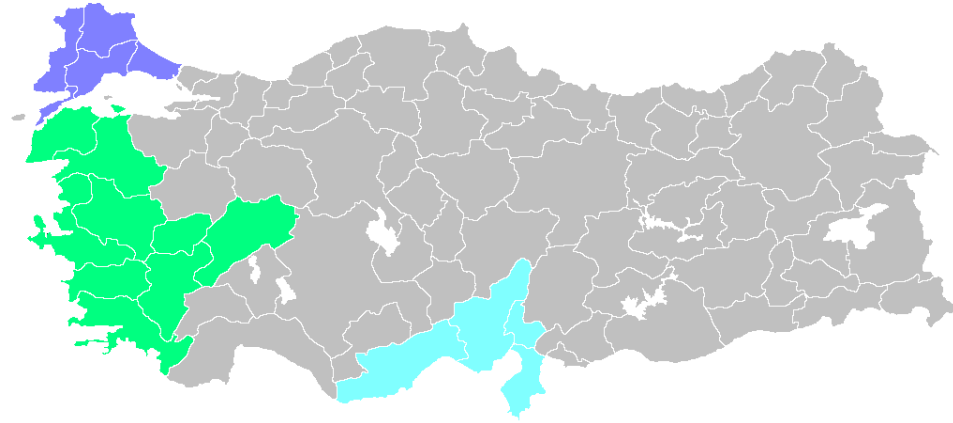


# DEVELOPMENT OF WIND ELECTRICITY GENERATION



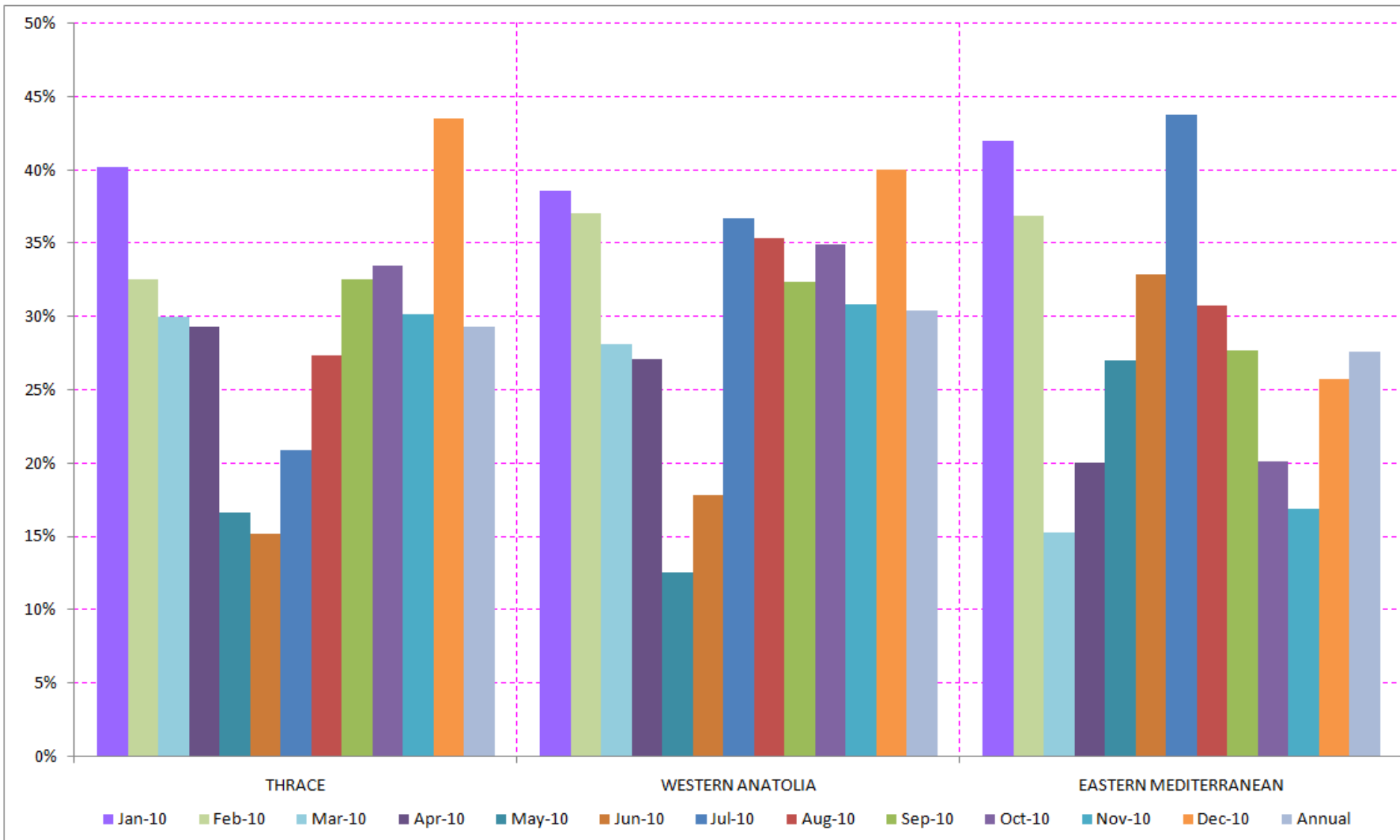


# HOURLY GENERATION ANALYSIS



- For the year 2010
- For 3 Load Dispatching Regions
  - Thrace, Western Anatolia and Eastern Mediterranean
- Hourly Generations of individual wind power plants are Accumulated to represent the region
- Hourly, Daily and Monthly
  - Capacity Factors
  - Generation Quality Indexes
  - Operating Hours according to 10-percent level of regional total installed capacity

# MONTHLY CAPACITY FACTORS



THRACE	WEST ANATOLIA	EAST MEDITERRANEAN
<b>5 Plants</b>	<b>7 Plants</b>	<b>5 Plants</b>
<b>128.6 MW</b>	<b>228.8 MW</b>	<b>243.0 MW</b>