REPUBLIC OF TURKEY
MINISTRY OF
ENERGY AND
NATURAL RESOURCES

TÜRKİYE ATOM ENERJİSİ KURUMU

NUCLEAR POWER PLANTS in TURKISH POWER SYSTEM

TURKISH DELEGATION

REPUBLIC OF TURKEY
MINISTRY OF
ENERGY AND
NATURAL RESOURCES

Contents

I. Turkish Power Grid

REPUBLIC OF TURKEY
MINISTRY OF
ENERGY AND
NATURAL RESOURCES

NUMBER OF SUBSTATIONS

- 400 kV: 92
- 220 kV: 1
- 154 kV: 566
- 66 kV: 14

Total 673 Subs. with 124.888 MVA transformer installed capacity.

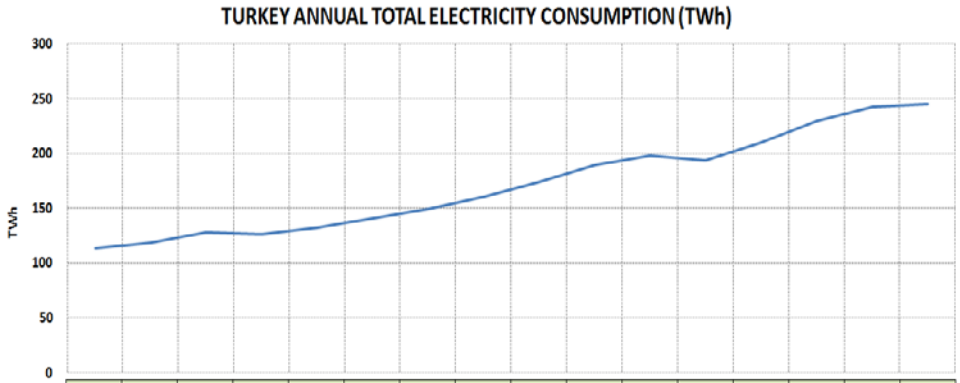
LENGTH OF TRANSMISSION LINES

- 400 kV: 17.328 km
- 154 kV: 34.741 km
- 220 kV: 85 km
- 66 kV: 509 km
- 154 & 400 kV UndergroundCable: 296 km
- Total 52.960 km

I. Turkish Power Grid

REPUBLIC OF TURKEY
MINISTRY OF
ENERGY AND
NATURAL RESOURCES

ENERGY CONSUMPTION



	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
CONSUMTION (TWh)	114	118.5	128.3	126.9	132.6	141.2	150	160.8	174.6	190	198.1	194.1	210.4	230.3	242.37	245.48
INCREASE (%)	8.1	3.9	8.3	-1.1	4.5	6.5	6.3	7.2	8.6	8.8	4.3	-2	8.4	9.4	5.2	1.2

FORECASTED VALUES

YEAR	PEAK DEMAND		ENERGY DEMAND	
	MW	GROWTH (%)	GWh	GROWTH (%)
2015	44260	4,6	287310	6,0
2016	46630	5,4	302700	5,4
2017	49100	5,3	318710	5,3
2018	51940	5,8	337130	5,8
2019	54970	5,8	356830	5,8
2020	58160	5,8	377490	5,8
2021	61260	5,3	397660	5,3
2022	64490	5,3	418590	5,3

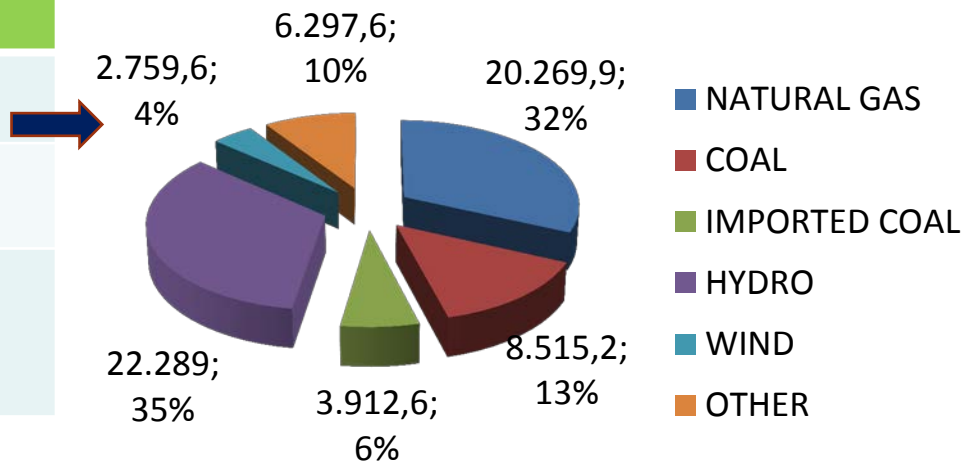
REPUBLIC OF TURKEY
MINISTRY OF
ENERGY AND
NATURAL RESOURCES

I. Turkish Power Grid

INSTALLED CAPACITY & PEAK LOAD

2012	
Installed Capacity:	57,071 GW
Consumption:	241,9 TWh
Peak Load:	39.045 MW

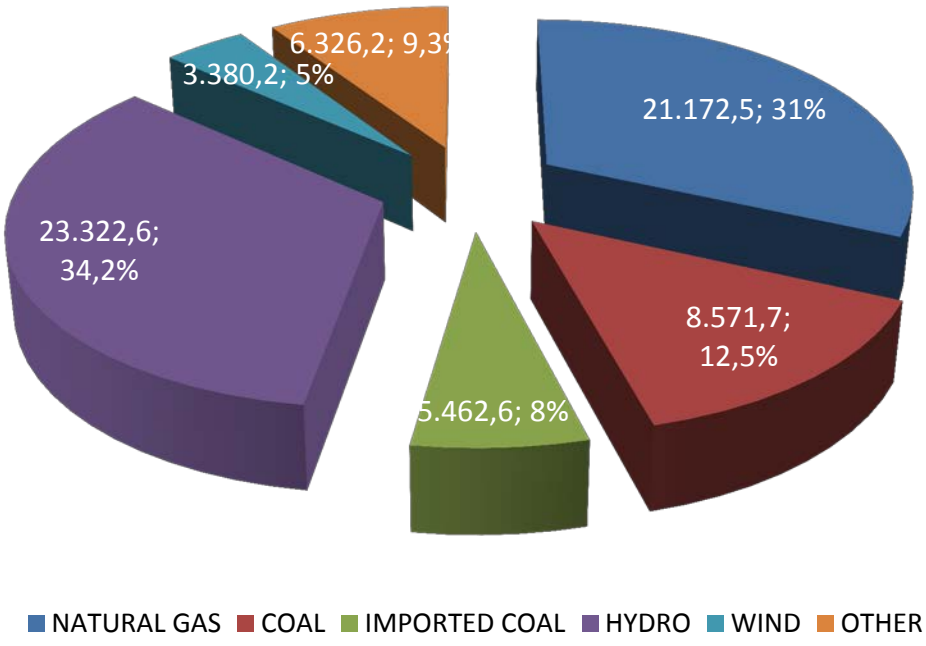
2013	
Installed Capacity:	64.044 MW
Consumption:	245,48 TWh
Peak Load:	38.274 MW



I. Turkish Power Grid

REPUBLIC OF TURKEY
MINISTRY OF
ENERGY AND
NATURAL RESOURCES

INSTALLED CAPACITY 2014



FUEL TYPE	INSTALLED POWER (MW)
NATURAL GAS	21.172,5
COAL	8.571,7
IMPORTED COAL	5.462,6
HYDRO	23.322,6
WIND	3.380,2
OTHER	6.326,2
TOTAL	68.235,9

- Installed capacity is 68.235 MW by 31 August 2014.

II. NPP Projects in TURKEY

REPUBLIC OF TURKEY
MINISTRY OF
ENERGY AND
NATURAL RESOURCES

Akkuyu NPP Project

- Contractor: ROSATOM
- Estimated Cost: 20 billion US $
- Reactor Type: VVER-1200 (AES-2006)
- Number of Units: 4 Units (1200 MW each)
- Operation Time: 60 years

II. NPP Projects in TURKEY

REPUBLIC OF TURKEY
MINISTRY OF
ENERGY AND
NATURAL RESOURCES

Sinop NPP Project

- IGA signed (May 3, 2013)
- HGA negotiation continuing
- MHI, Itochu, GDF Suez and EUAS (%30-49)
- EUAS has been recognised as "founder"
- Site evaluation studies are being done

III. Grid Integration

REPUBLIC OF TURKEY
MINISTRY OF
ENERGY AND
NATURAL RESOURCES

- **Akkuyu NPP is planned to be in operation in 2020-2023 four unit respectively**

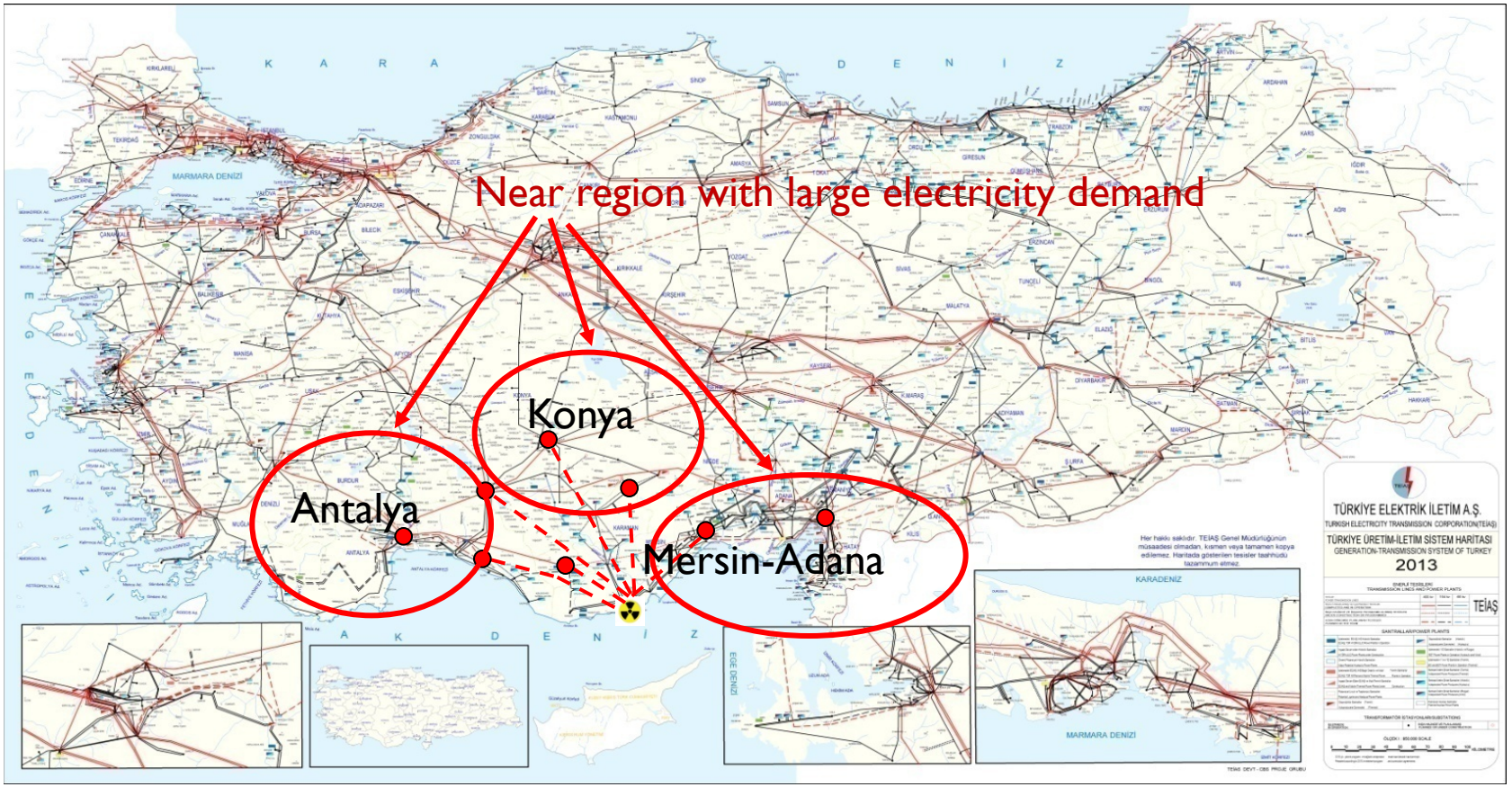
- **Sinop NPP is planned to be in operation in 2023-2024 for units I-II and in 2027-2028 for units III-IV**

- **In 2022, total energy and peak power demand of Turkish Grid is expected ~418TWh & ~64GW**

- **Akkuyu NPP is expected to operate at 90% capacity factor, which will provide ~9% of annual energy demand and will support 7.5% of peak power in 2022.**

III. Grid Integration

GRID INTEGRATION- AKKUYU CASE

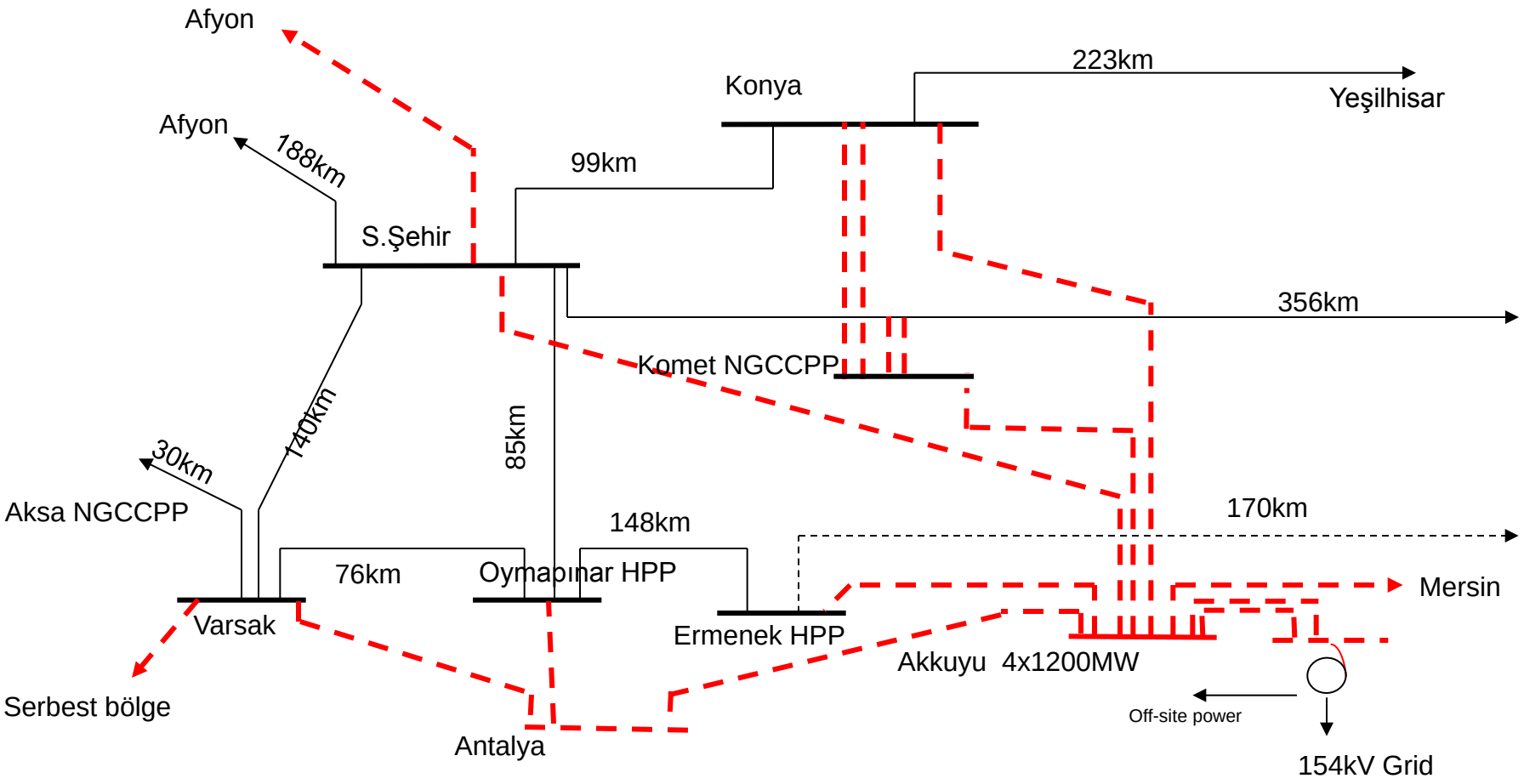


# of 400kV, 6 single circuit transmission line is necessary for grid connection of Akkuyu NPP, totally ~1000km. 4 of 6 lines are approved in TEİAŞ's official investment plan and site studies has been started. Lines will be tendered in 2014. Remaining two lines will be contracted later.

III. Grid Integration

GRID INTEGRATION- AKKUYU CASE

400kV Connections of Akkuyu NPP

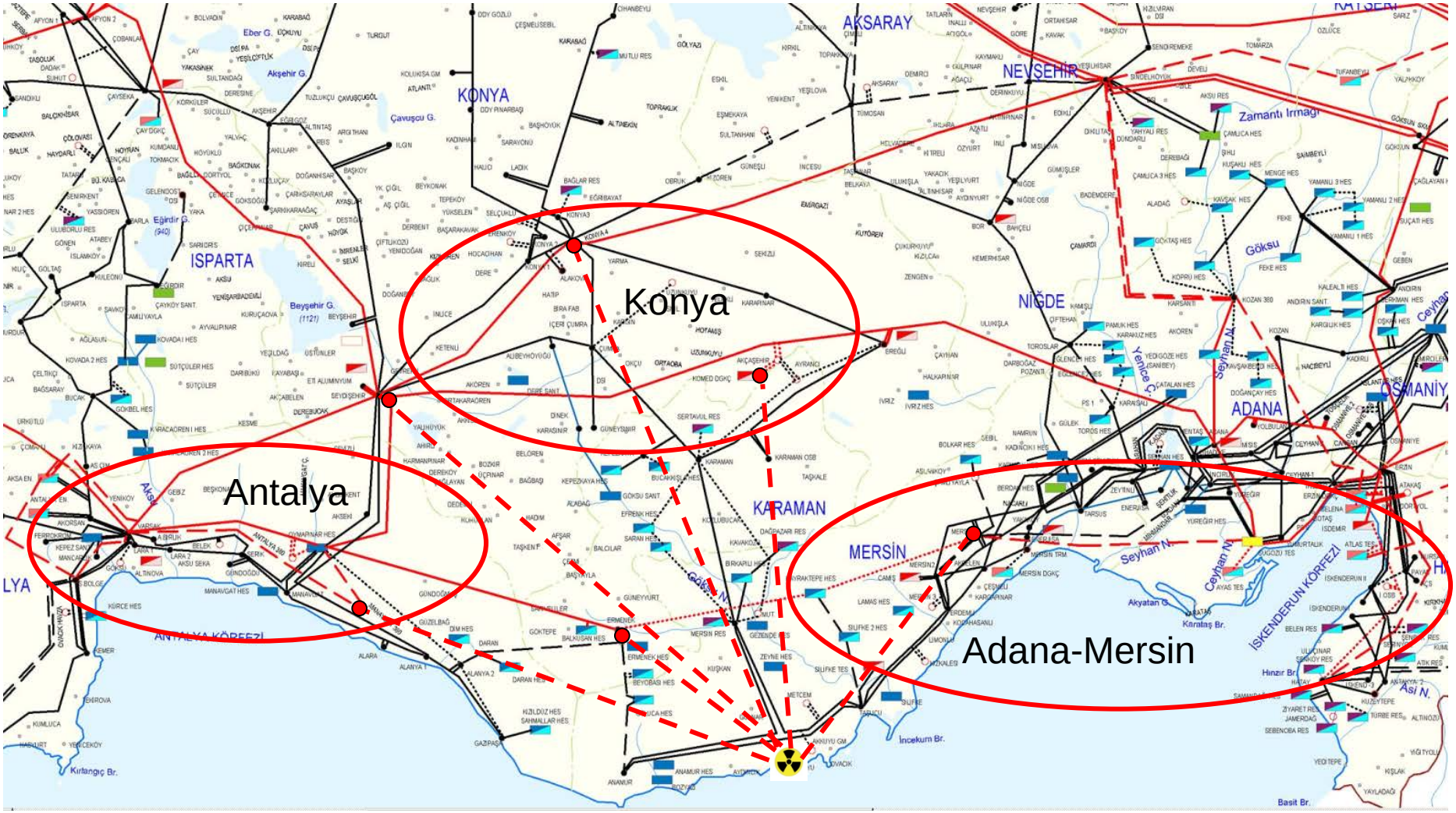


NGCCPP, Natural Gas Combined Cycle Power Plant
HPP, Hydro electric Power Plant

REPUBLIC OF TURKEY
MINISTRY OF
ENERGY AND
NATURAL RESOURCES

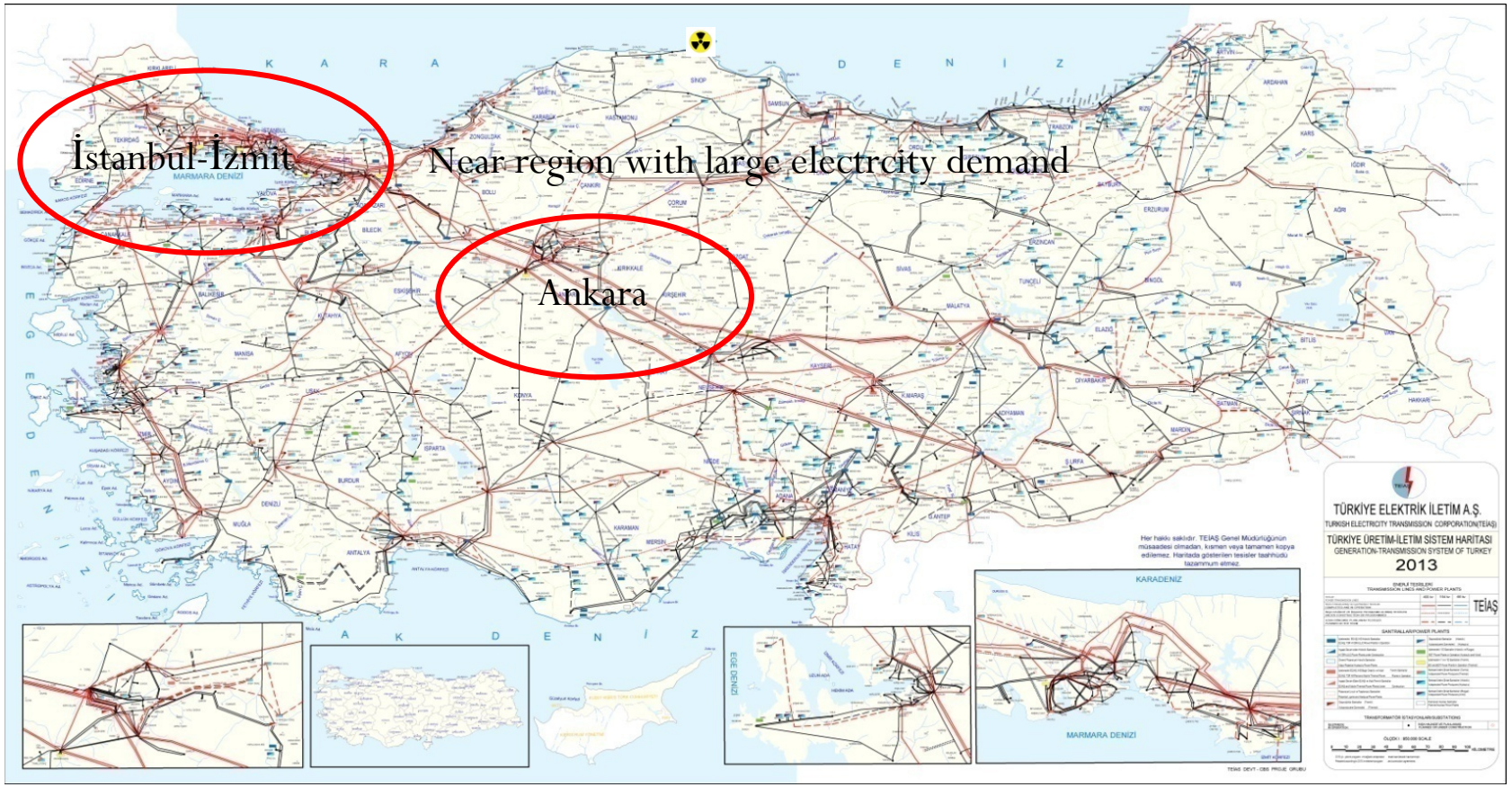
III. Grid Integration

GRID INTEGRATION- AKKUYU CASE



III. Grid Integration

GRID INTEGRATION- Sinop CASE

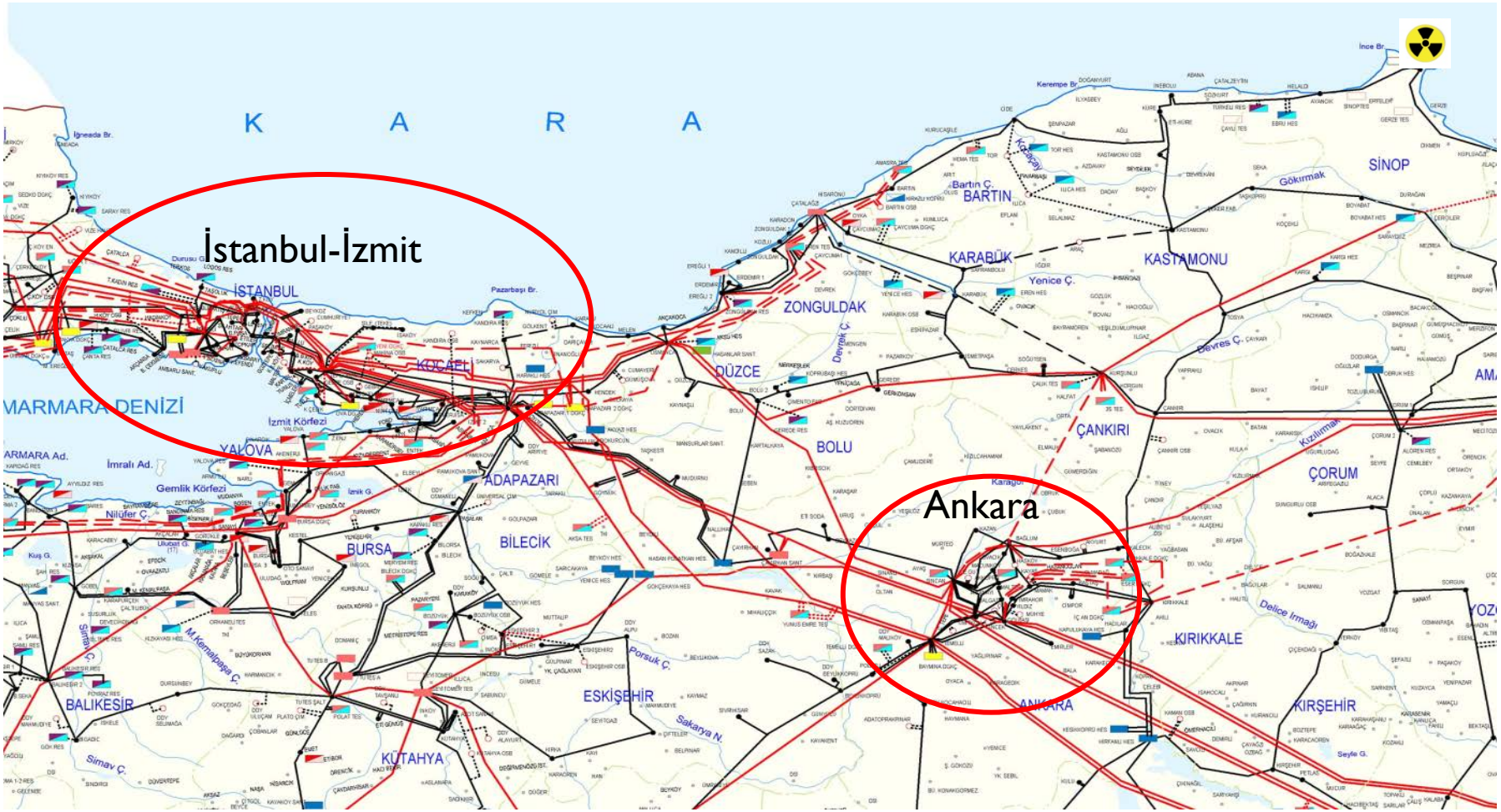


Principle grid integration study is started. Existing grid; which is very weak in Sinop site; line routes, new substations are being evaluated. Draft studies shows that Sinop Project requires more grid investment than Akkuyu NPP does due to lack of big demand center and ongoing coal fired power plants in the same area

III. Grid Integration

REPUBLIC OF TURKEY
MINISTRY OF
ENERGY AND
NATURAL RESOURCES

GRID INTEGRATION- Sinop CASE



400kV, ~1400km transmission line is necessary to provide secure and reliable grid connection of Sinop NPP

IV. Integration to National Grid Code

REPUBLIC OF TURKEY
MINISTRY OF
ENERGY AND
NATURAL RESOURCES

Frequency control in grid code

•Every generation unit which has a 50 MW installed capacity or above has to contribute to Primary Frequency Control.

•Every generation unit which has a 100 MW installed capacity or above must be able to contribute to secondary control according to their ancillary service agreement anytime their contribution is needed. (Min 5% of Installed Capacity)

IV. Integration to National Grid Code

REPUBLIC OF TURKEY
MINISTRY OF
ENERGY AND
NATURAL RESOURCES

Primary frequency regulation (PFR):

- **Primary frequency reserve of 1%Pnom**

- **Power change is to take place within 30 seconds, whereas achievement of 100% of the required power with ±%10 tolerance rate**

- **Power change can be max15 minutes**

- **Taking into account plant safety dead band value determined by TEİAŞ and power plant operator**

Primary control is a prerequisite for connection to the grid. (EUR, 2001)

IV. Integration to National Grid Code

REPUBLIC OF TURKEY
MINISTRY OF
ENERGY AND
NATURAL RESOURCES

Secondary frequency regulation (SFR): Purpose:

- **To keep the system frequency close to the nominal value (50 Hz).**
- **To restore interchange with the other countries at the scheduled value.**

Participation on secondary control is based on agreement between the grid operator and the electricity production company. The secondary control is central control. (Manuel or Automatic.)

IV. Integration to National Grid Code

REPUBLIC OF TURKEY
MINISTRY OF
ENERGY AND
NATURAL RESOURCES

Why joining Secondary Frequency control not preferable for NPP Owner?

- Can not utilize the fuel best economic way
- Unstable reactor power
- Change in burn up
- Increase in radioactivity
- Earlier refueling period
- Increase in waste
- No operating VVER joining SFC
- Automatic AGC signal

IV. Integration to National Grid Code

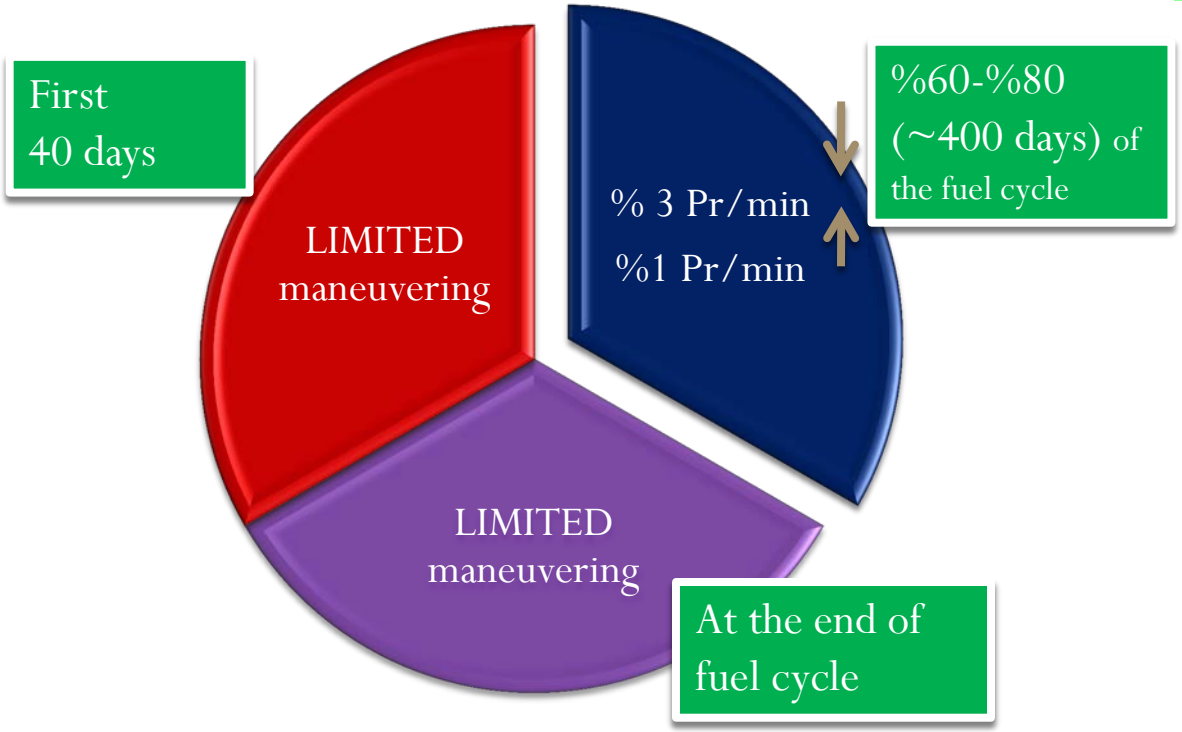
REPUBLIC OF TURKEY
MINISTRY OF
ENERGY AND
NATURAL RESOURCES

In which circumstances NPPs cant join SFC?

- The standart fuel cycle length is **4 years.**

18-20 months long fuel operation is possible along with the fuel operation as per the standart fuel cycle.

- The length between refuelings is **18 months**



Grid Code

It is supposed the NPP takes part in the secondary regulation of frequency at the following parameters:

- Minimum volume of reserve capacity for the nuclear power plants shall be 5% of Nnom;
- Capacity reduction/increase rate within the range of 1% to 5% Nnom/min.

IV. Integration to National Grid Code

REPUBLIC OF TURKEY
MINISTRY OF
ENERGY AND
NATURAL RESOURCES

In which circumstances NPPs cant join SFC?

Other limitations;

the operation modes of Akkuyu turbine plant will be provided in the following frequency bands

Frequency band (Hz)	Maximal operation duration for every single case	Maximal operation duration for full service life
51,5 ≤f≤ 52,5	10 minutes	(new grid code)
50,5 – 51,5	60 minutes	4 hours
49 – 50,5	unrestricted	unrestricted
48,5 - 49	60 minutes	100 hours
48 – 48,5	20 minutes	100 hours
47,5 - 48	10 minutes	4 hours

IV. Integration to National Grid Code

REPUBLIC OF TURKEY
MINISTRY OF
ENERGY AND
NATURAL RESOURCES

Secondary Frequency Control solution;

• Change in grid code:

Nuclear Power Plants must join secondary frequency control at most %5 of nominal power with the increase or decrease rate of %1 to %5 per minute.

•Nuclear power plants must have the capability to increase or decrease power at the rate of %1 when they are able to join SFC

•Taking into account safe operation conditions power plant operator and TEİAS will agree on which circumstances and period's nuclear power plant can or cannot join SFC.

•Capabilities will be determined during grid connection tests and those periods will be in grid usage agreement.

IV. Integration to National Grid Code

REPUBLIC OF TURKEY
MINISTRY OF
ENERGY AND
NATURAL RESOURCES

Other changes in Grid Code;

Number of lines:

- Regardless of total power and unit number nuclear power plants will connect the grid with N-2 criteria. (it was N-1 for all power plants)

IV. Integration to National Grid Code

Other changes in Grid Code;

Power Output:

Old

Units should have the capacity to satisfy rated power output between 0.85 power factor of overexcited operation and 0.95 power factor of underexcited operation.

New

Nuclear Power Units should have the capacity to satisfy rated power output between 0.9 power factor of overexcited operation and 0.95 power factor of underexcited operation.

IV. Integration to National Grid Code

Other changes in Grid Code;

Power Output:

Reasons:

- the lower the power factor the larger will be the generator – (economical reason,)
- similar design generators with lower power factor have lower efficiency,
- similar design generators with lower power factor have lower Short Circuit Ratio (SCR): SCR will be < 0.5 if Power Factor is < 0.90,
- a value of reactive power of large generator has big influence on the power system in that it can change the system's voltage. As excess of the reactive power in the system can increase system's voltage and lead to failure of outstanding electrical equipment, the reactive power in the system shall be definitely limited.

IV. Integration to National Grid Code

Excitation sytem static or brushless ?

Grid Code :

If the unit is exposed to a drastic voltage change, the excitation control system whose output is controlled by the automatic voltage regulator, should be able to reach lower and upper voltage limits of the generator warning winding in no longer than 50 milliseconds.

This is only satisfied by static excitation system;

- **Brushless excitation system advantages** :
- High reliability and lifetime operational capability of the excitation technical features
- Absence of slip rings and brush gear, no need for an additional third bearing, extreme compactness and shorter shaft line and foundation table.
- With this system there are immanent high dynamic performances and efficient contribution to the grid stability. (Particularly in case of long grid fault).
- As there are no carbon brushes the maintenance effort is considerable lower.
- Reduced sizes of excitation transformer, commutation equipment, and current leads.

TEİAŞ confirmed that Akkuyu NPP can use Brushless excitation system without change in grid code.

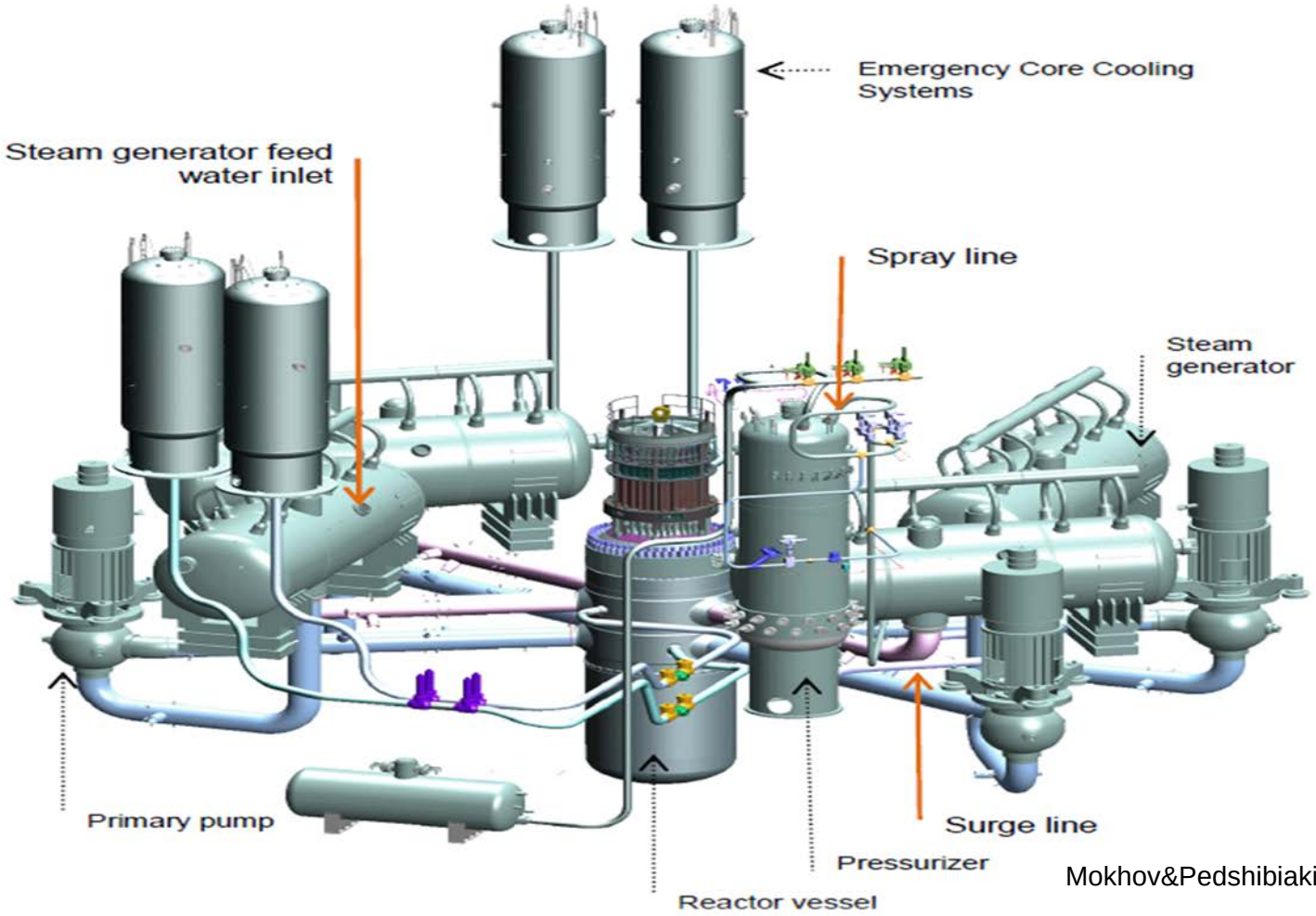

MINISTRY OF
ENERGY AND
NATURAL RESOURCES
REPUBLIC OF TURKEY
THANK YOU...

II. NPP Projects in TURKEY

THE MANOEUVRING CAPABILITY OF THE VVER 1200

Conditions	AES-2006	EUR
Primary control		
Change in Unit power	not more than ±5 % Nnom	±5 % Nnom
Rate of power change	1 % Nnom/s	Not regulated
Number of cycles	$7 \cdot 10^6$	Not regulated
Secondary control		
Change in Unit power	not more than ± 10 % Nnom	not more than ± 10 % Nnom
Rate of power change	not more than 5 % Nnom/min	not more than 5 % Nnom/min
Number of cycles	$5 \cdot 10^6$	Not regulated
Power change of the Unit according to the schedule		
Power change of the Unit	50-100-50 % Nnom	20-100-20 % Nnom
Rate of power change	not more than 5 % Nnom/min	not more than 3 % Nnom/min
Number of cycles	15000 (5 times a week)	2 time/day, 5 times/week 200 times/year

VVER 1200 CRITICAL ELEMENTS FOR LOAD FOLLOWING (**orange arrow**)



Mokhov&Pedshibiakin, 2010