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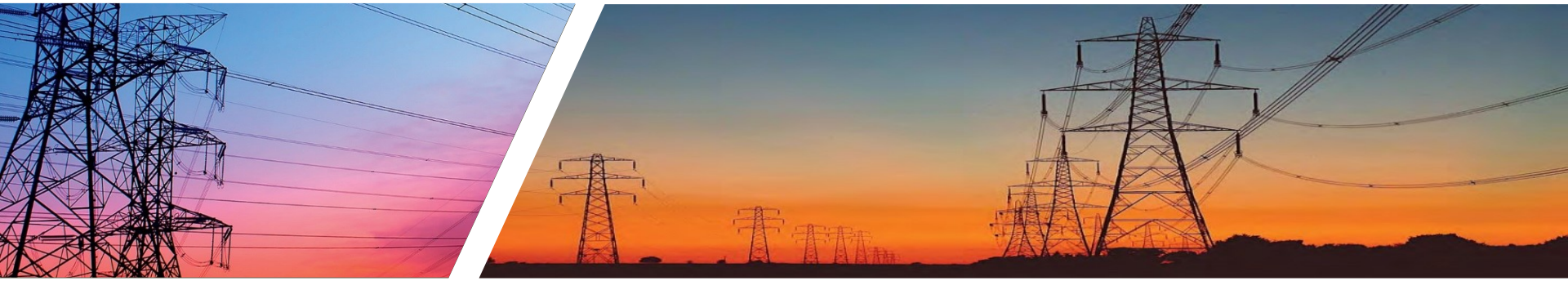

TRANSMISSION AND DISTRIBUTION NETWORK CHALLENGES WITH LARGER SCALE RES INTEGRATION

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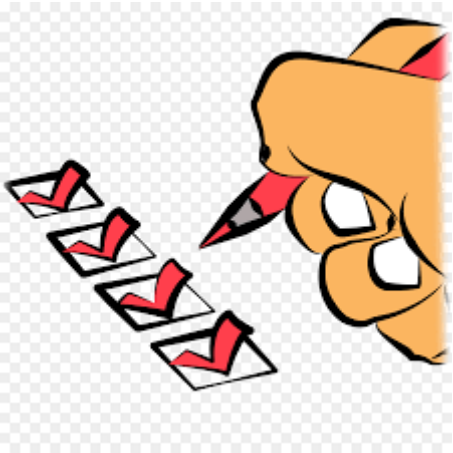
PPL session "Development of energy infrastructure: transmission and distribution grids and energy storage"
17 December 2020

CONTENT



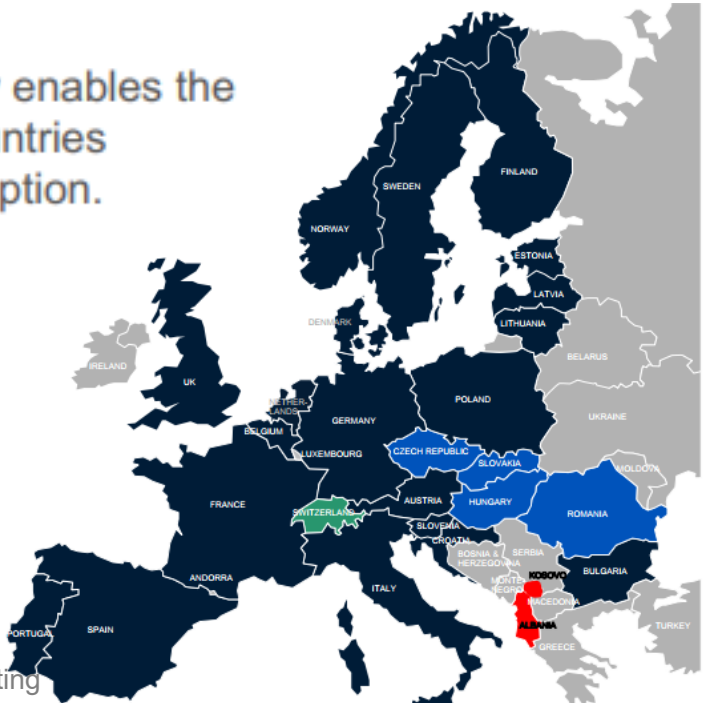
1) Introduction
2) Quality of TSO/DSO service
3) Ancilary services
4) Network planning

WHY IS NETWORK IMPORTANT ?

1) **Initially not designed** for large market activities or DG
2) Generation capacity and location is **rapidly changing**
3) Introduction of **user response**

The Price Coupling of Regions (PRC) initiative now enables the coupling of Day Ahead electricity markets in 23 countries representing over 90% of European power consumption.

- **Part of PCR initiative today**
- **4 MMC**
- **Independent**



Source:
EPEX, NordPool Consulting

HISTORY OF PARALLEL OPERATION

1951 UCPTE

1960 OES

1961 UFIPTE

1963 NORDEL

1974 SUDEL (exYU)

1977 SUDEL (GR)

1985 ALBANIA

UKTSOA

ATSOI

1991 War in ex YU

1992 CENTREL

1993 disconnection USSR and RO, BG ⇨2. sin.zone UCPTE

1995 CENTREL and DDR ⇨ UCPTE

1997 MO, DZ and TN MAGREB ⇨ UCPTE

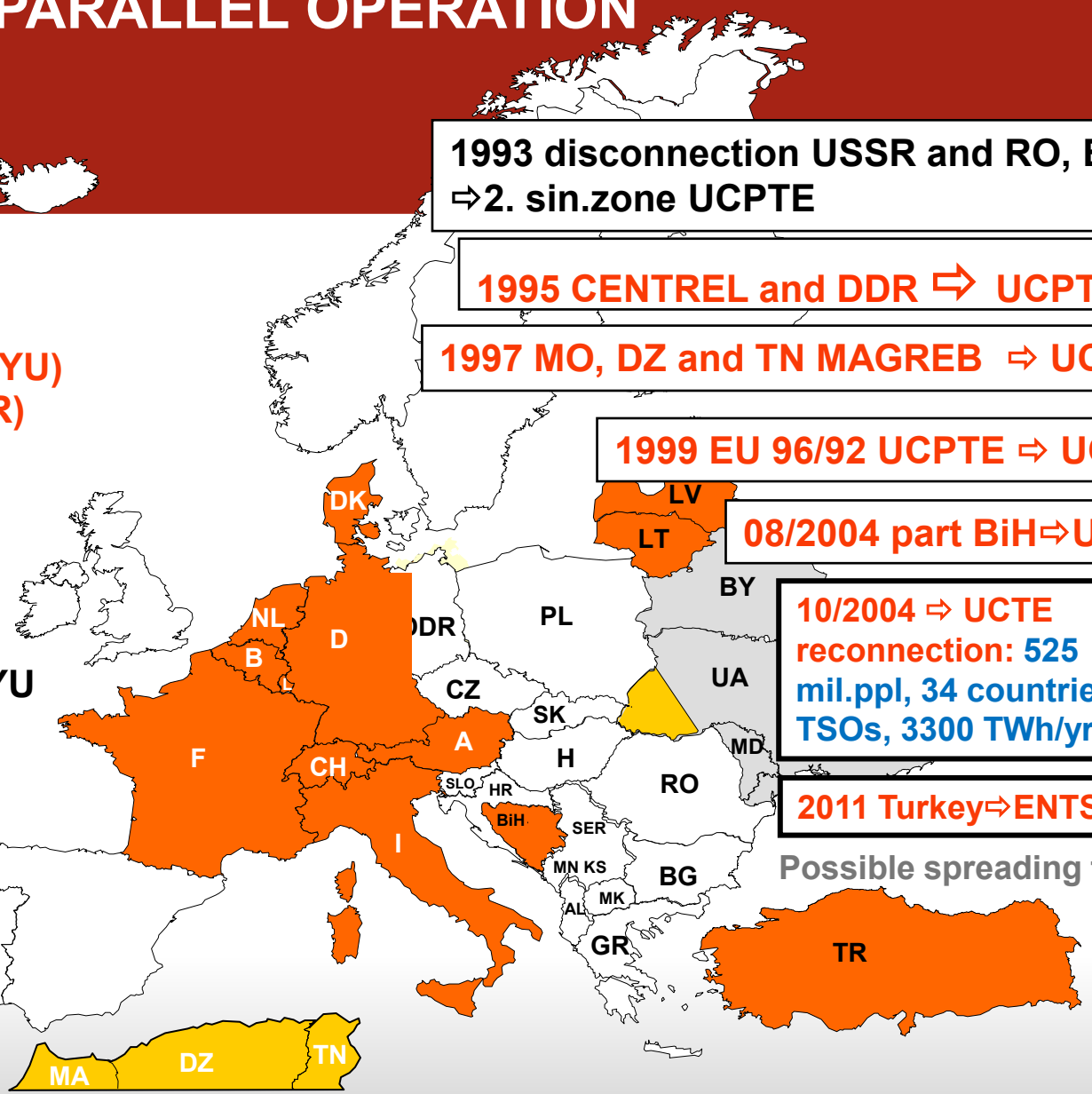
1999 EU 96/92 UCPTE ⇨ UCTE

08/2004 part BiH⇨UCTE

10/2004 ⇨ UCTE reconnection: 525 mil.ppl, 34 countries, 42 TSOs, 3300 TWh/yr

2011 Turkey⇨ENTSO-E

Possible spreading to east



Source: ENTSO-E

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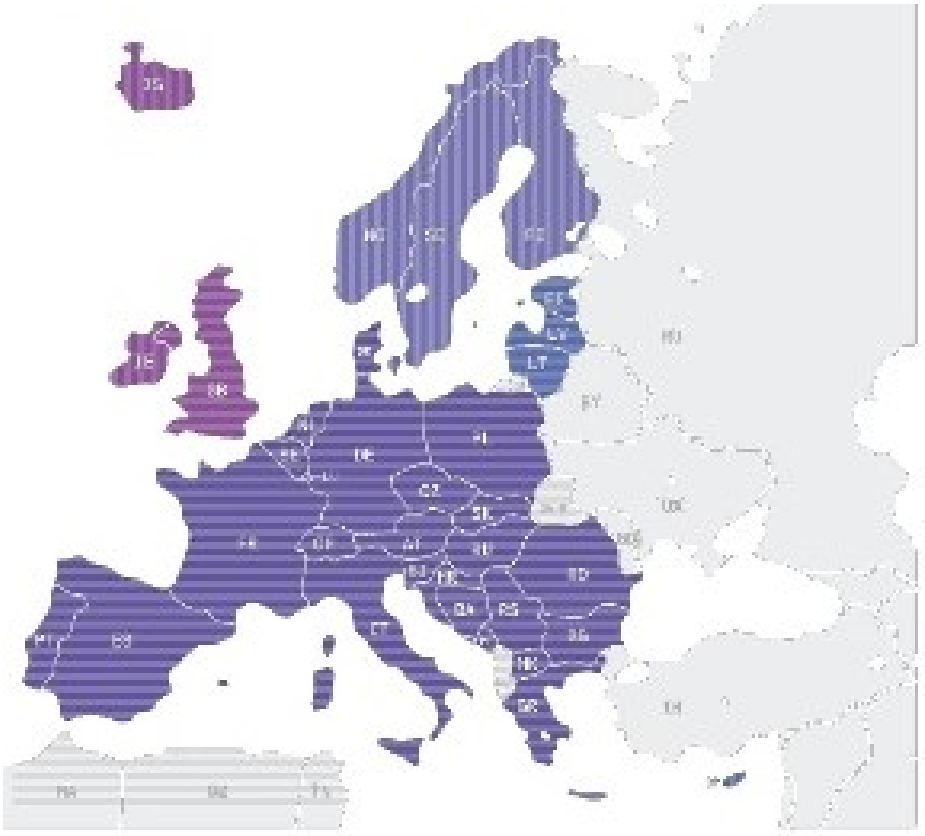
EUROPEAN POWER SYSTEM TODAY

41 TSOs
from 34 countries

532 million
citizens served

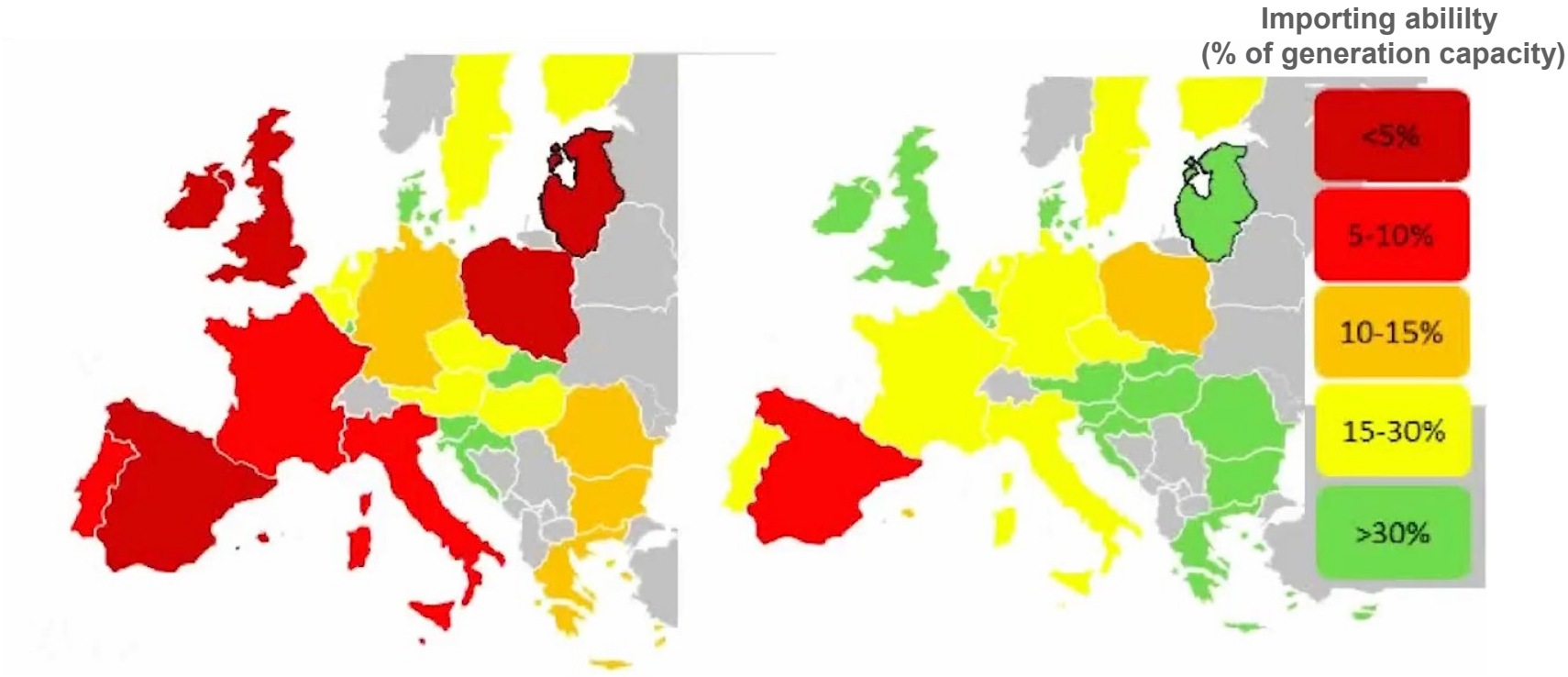
828 GW
generation

305 Thousand Km
of transmission lines



the largest synchronous electrical grid in the world by connected power

WHY IS THIS IMPORTANT ?



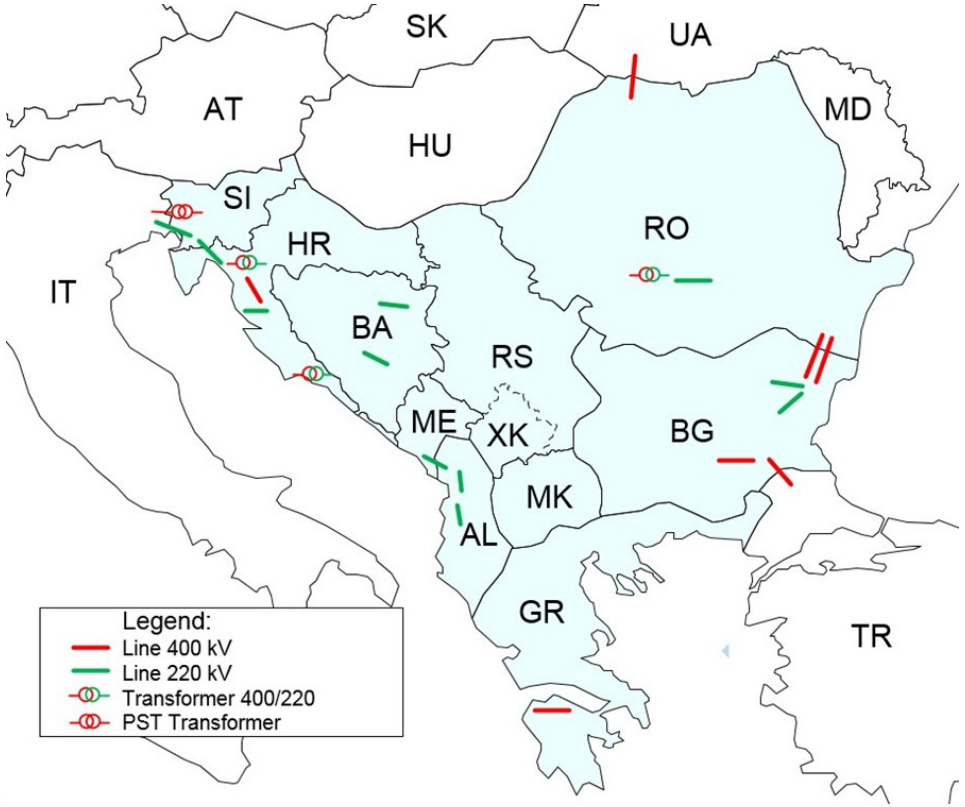
Currently

After implementation of projects of common interest (PCI)

TARGET: Remove red colors !

Source: DG Energy

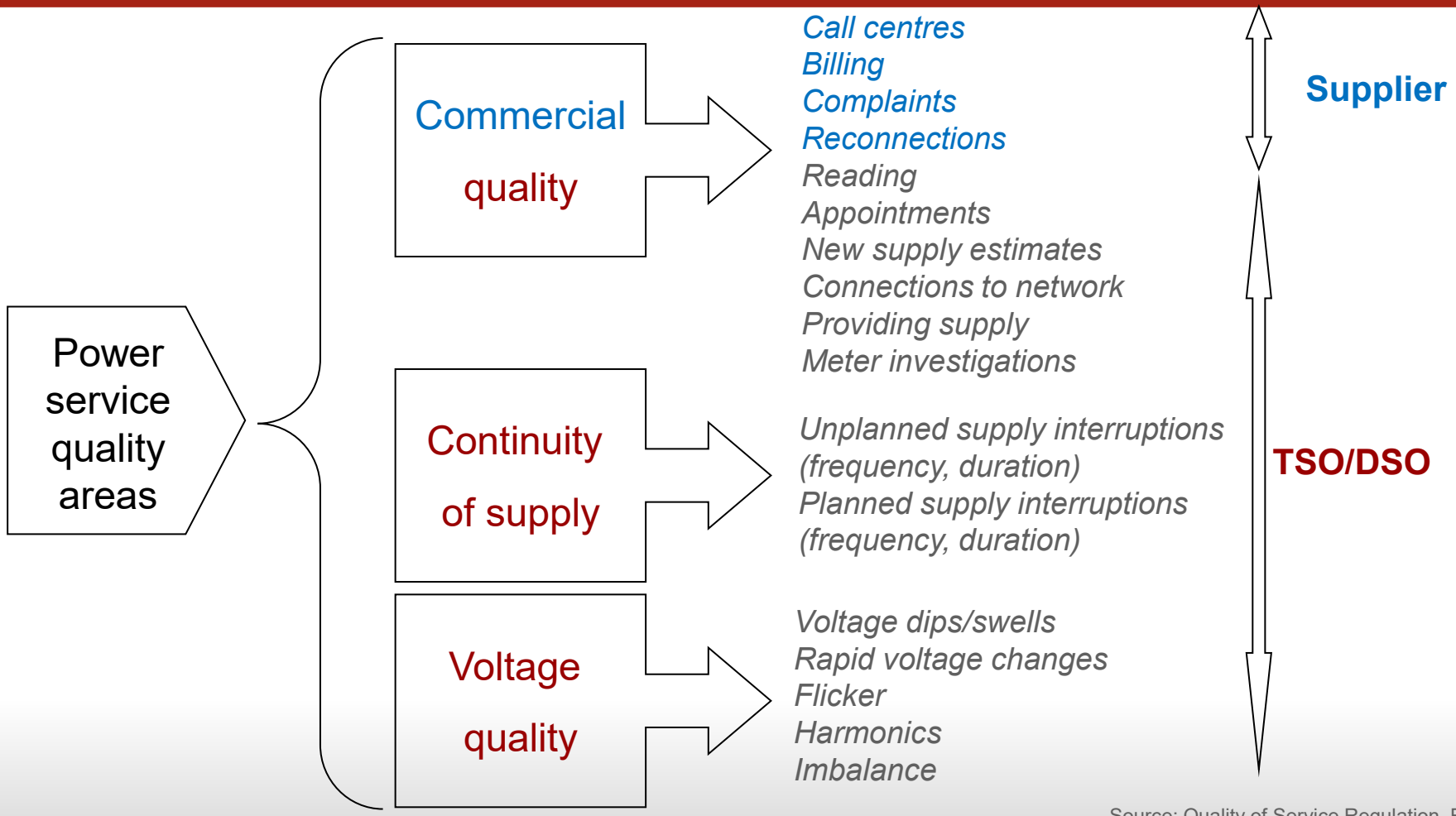
HIGH RES CAUSES SEVERAL NEW NETWORK BOTTLENECKS IN 2030



Just 22 detected critical network elements in all large RES scenarios ➔ clear evidence of robust and well-planned network

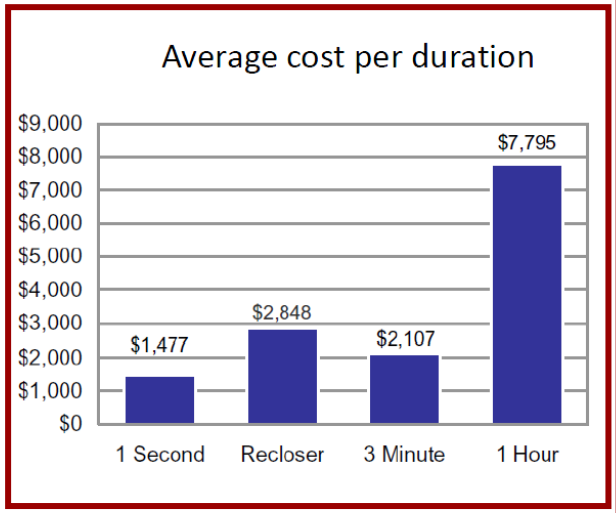
#2 QUALITY OF TSO / DSO SERVICE

TSO/DSO SERVICE QUALITY



Source: Quality of Service Regulation, EnCS

WHY IS TSO/DSO QoS IMPORTANT ?



Source: EPRI - The Cost of Power Disturbances to Industrial and Digital Economy Companies

Half of all computer problems and one-third of all data loss can be traced back to the power line… Contingency Planning Research, 1996

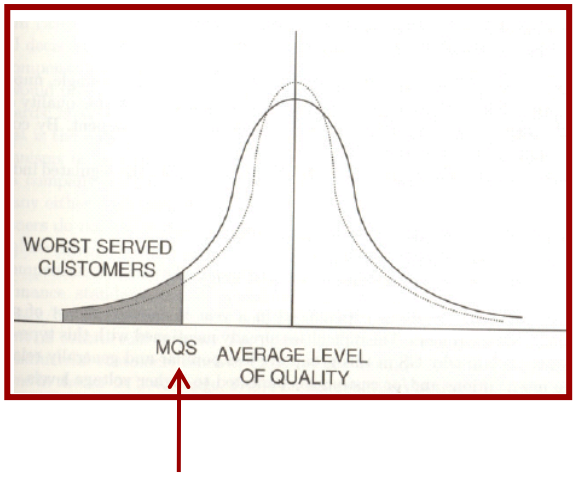
A manufacturing company lost more than $3 million one day last summer in Silicon Valley when „light went out"…. New York Times, 2000

Berkeley Lab Study Estimates $80 billion Annual Cost of Power Interruptions…. Berkeley Lab, 2005

30-40 % of all business downtime is related to power quality problems… Electric Power and Light Magazine, 2008

$50 Billion per year in the USA is lost as result of power quality breakdowns… Bank of America Report 2012

TSO/DSO SERVICE QUALITY INDICATORS



System-level:

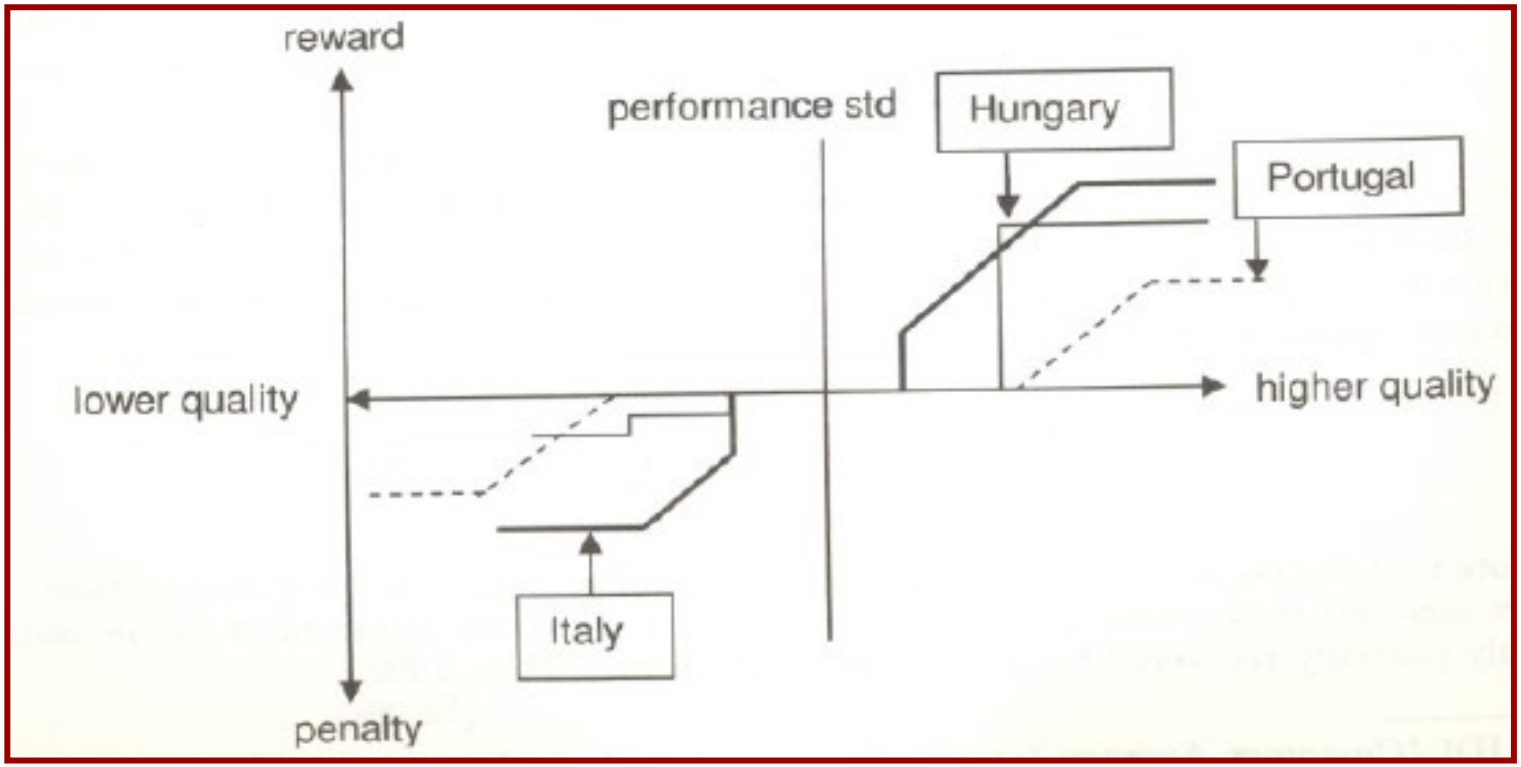
- ***Advantage:*** *represents the system quality level in a compact way*
- ***Disadvantage:*** *can hide low quality areas*

Individual:

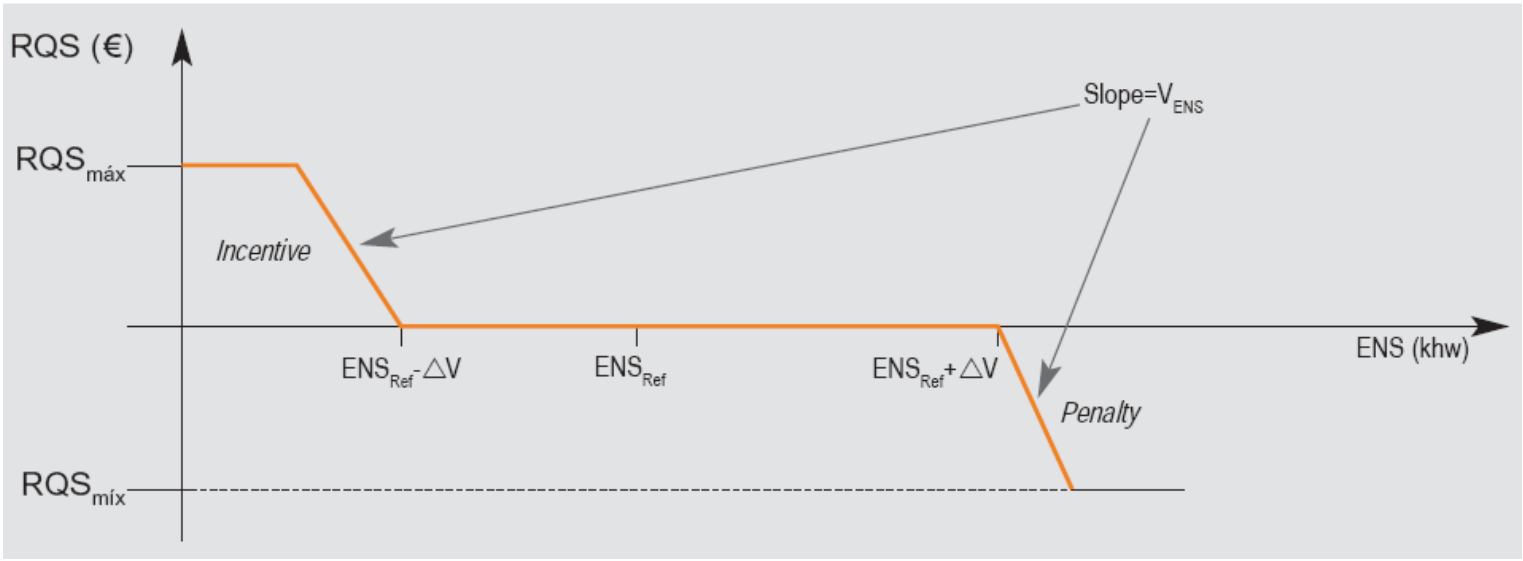
- ***Advantage****: measures the quality level offered to each customer*
- ***Disadvantage:*** *necessary equipment to measure them; high costs*

QoS introduced in: Italy – 2000, Norway, Ireland – 2001, UK – 2002, Hungary, Portugal – 2003, Sweden – 2004

ELECTRICITY NOT SUPPLIED -TSO/DSO incentive scheme-



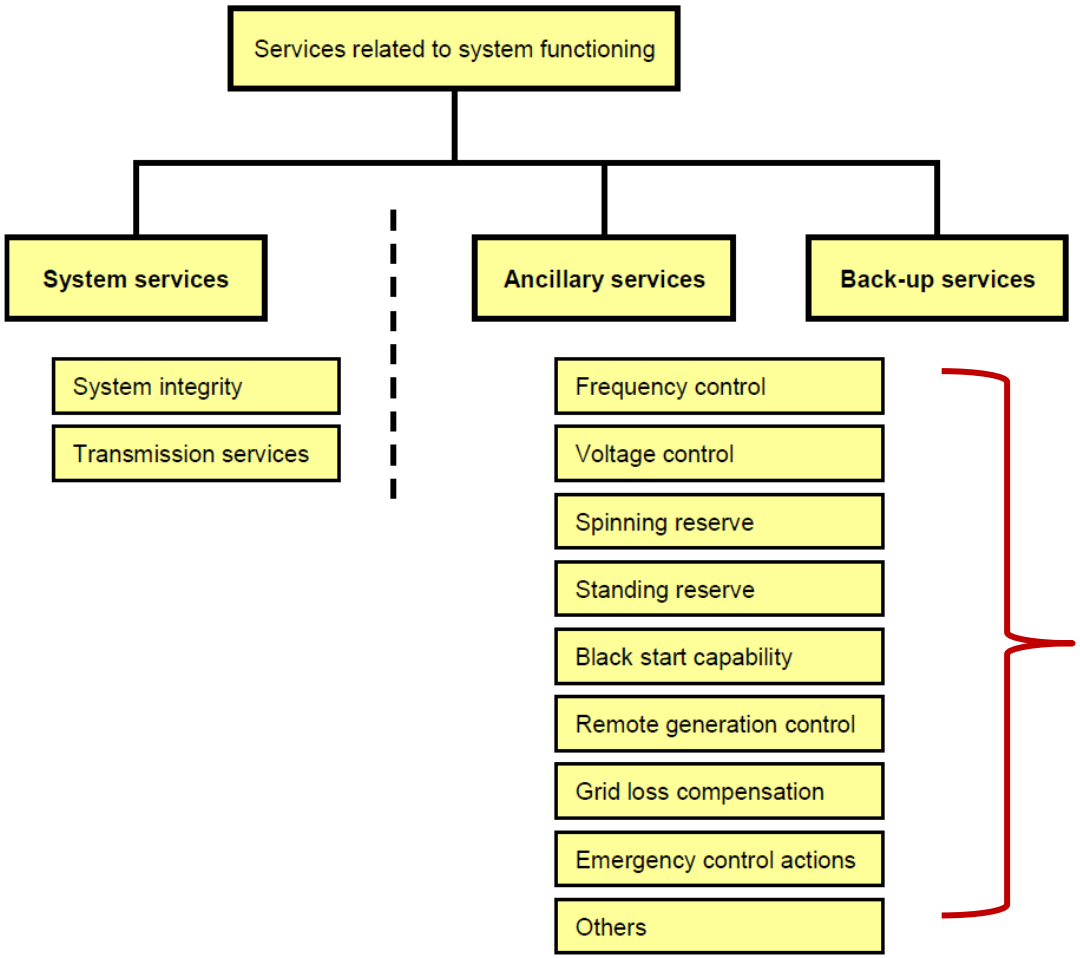
TSO/DSO ENS INCENTIVE SCHEME – Portugese case -



- The reward and the penalty have the same maximum value: $|RQS_{min}| = |RQS_{max}| =$ 5 000 000 €
- Target: ENS_{Ref} = 0,0004 x ES (ES=energy supplied in the year)
- Dead band: ± △V = 0,12 x ENS_{Ref}
- Value of ENS: V_{ENS} = 1,5 €/kWh

#3 ANCILLARY SERVICES

ANCILLARY SERVICES DEFINITION



*"services required by the TSO and DSO to enable them to maintain the **integrity and stability** of the transmission or distribution system as well as the **power quality**."*

FREQUENCY CONTROL EXAMPLE

Analogy with lake, inflows and sinks…

water level in the lake should remain constant all the time no matter of variable inflows and sinks – we need regulating source

Problem: **„regulating source" is not TSO/DSO property – need to be purchased**

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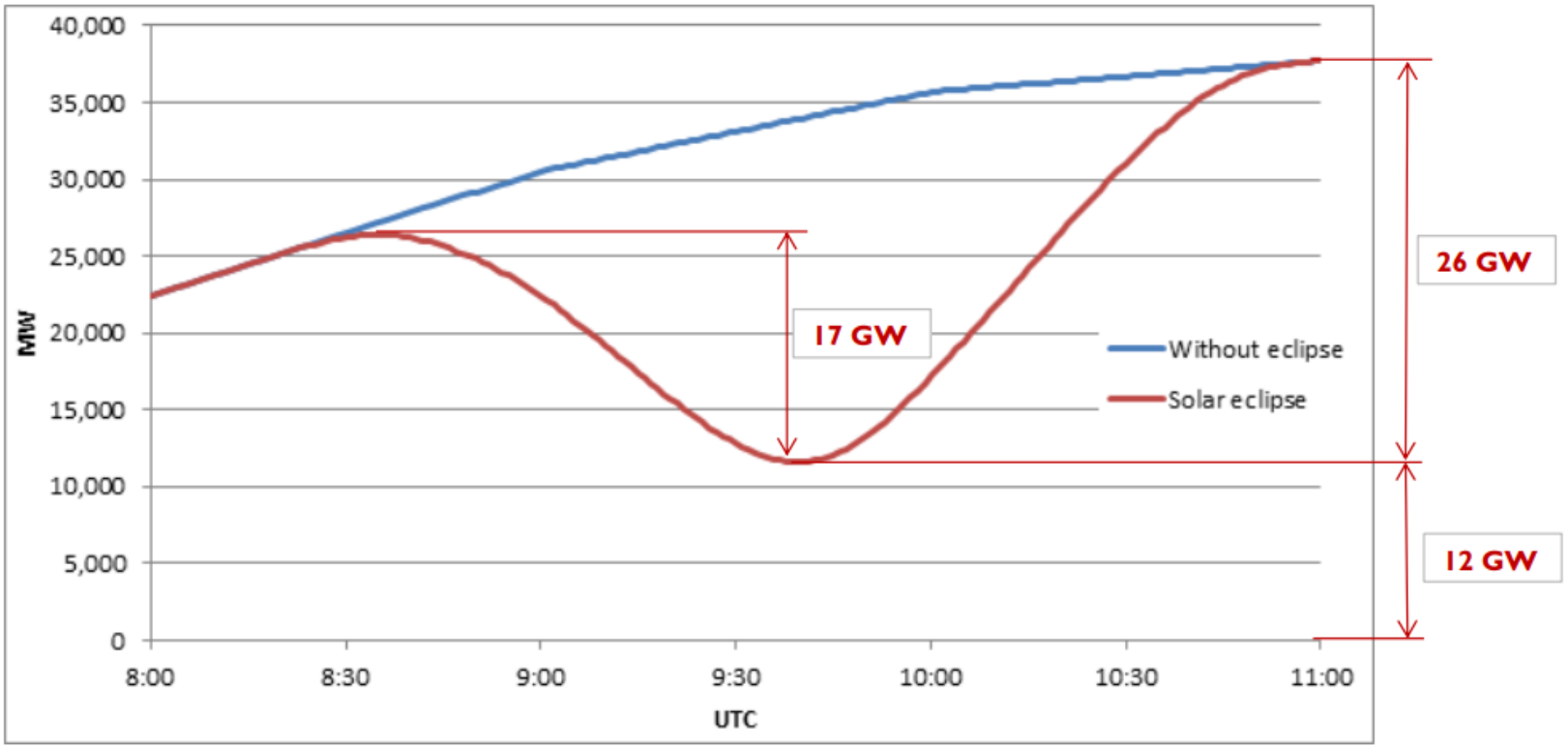
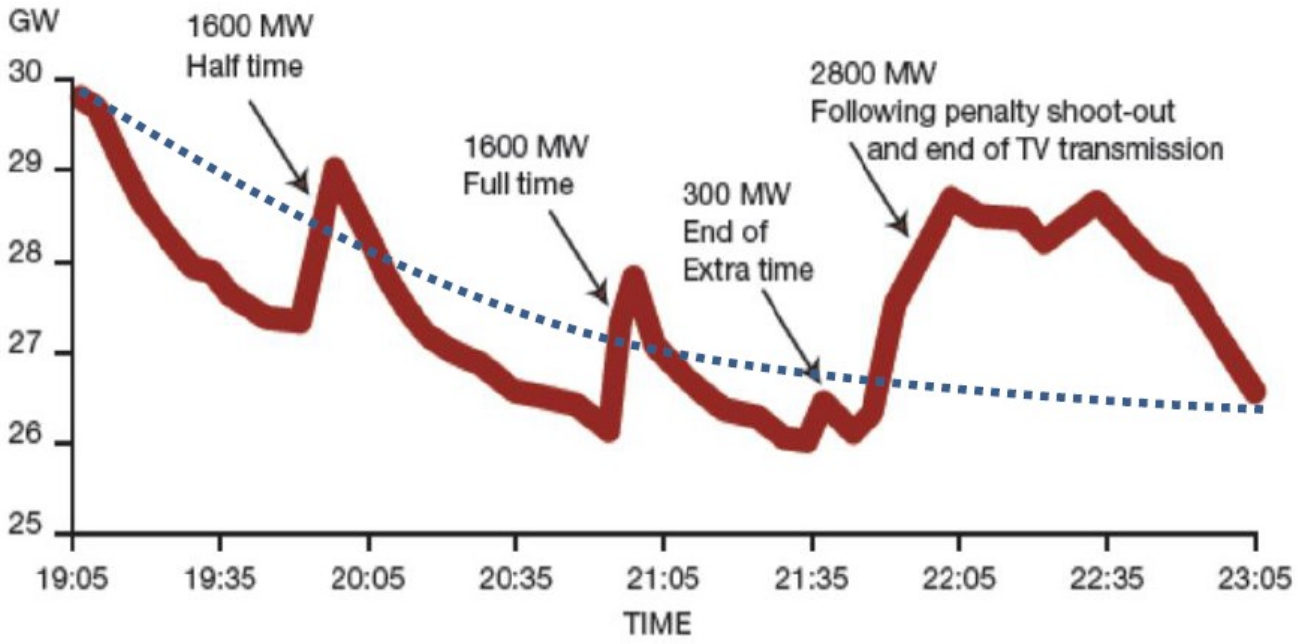
FREQUENCY CONTROL EXAMPLE



Solar eclipse, PV generation, Europe 20.3.2015
(similar in the USA 21.7.2017)

FREQUENCY CONTROL EXAMPLE

England Vs Germany 1990, World Cup Semi-Final, Kick Off 19:00



Source: NGC

ANCILLARY SERVICES EXPERIENCE

over 20 years

United Kingdom

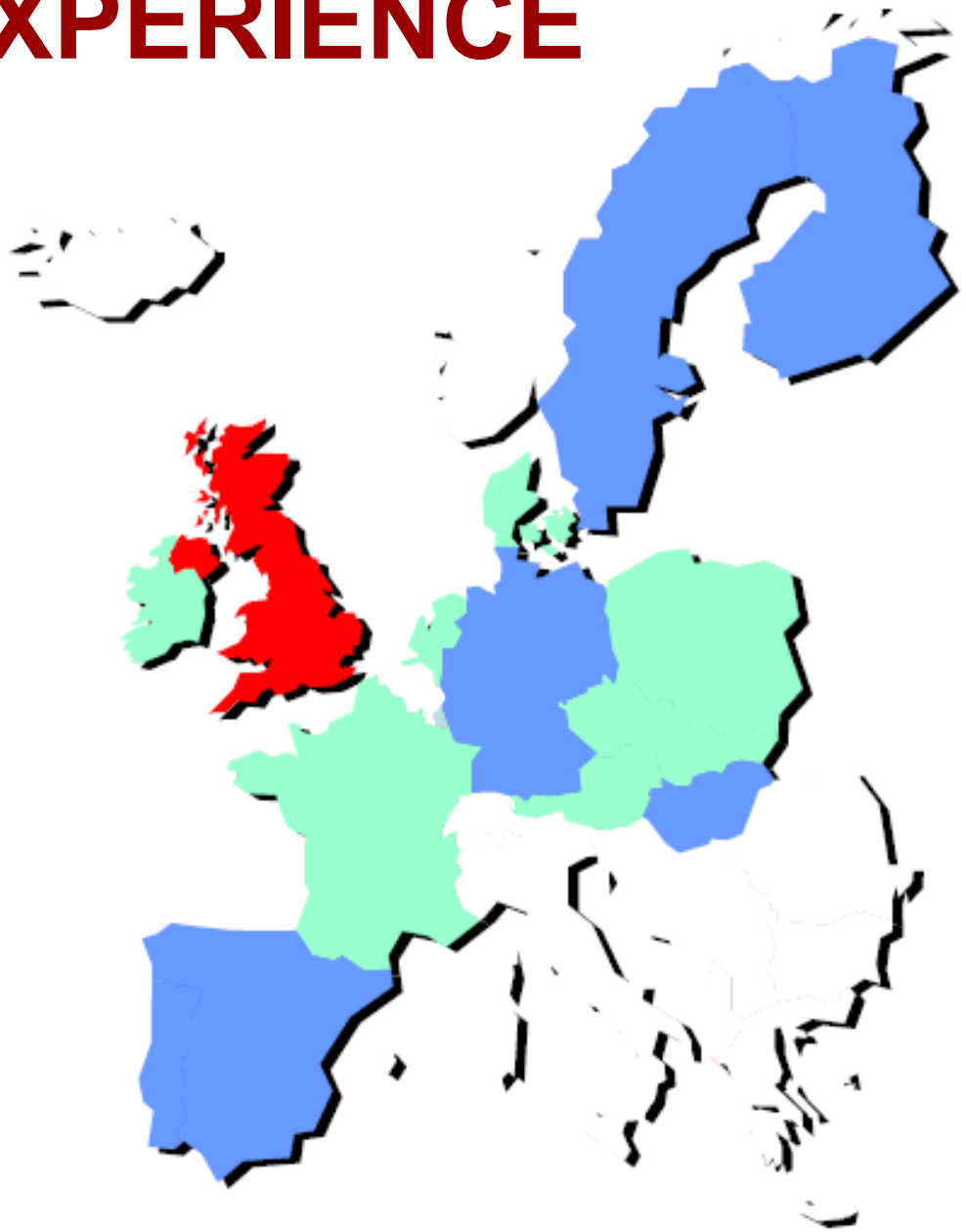
15 - 20 years

Finland
Germany
Hungary
Portugal
Spain
Sweden

10 - 15 years

Austria
Czech Republic
Denmark
France
Ireland
Netherlands
Poland
Slovakia

10 years or less



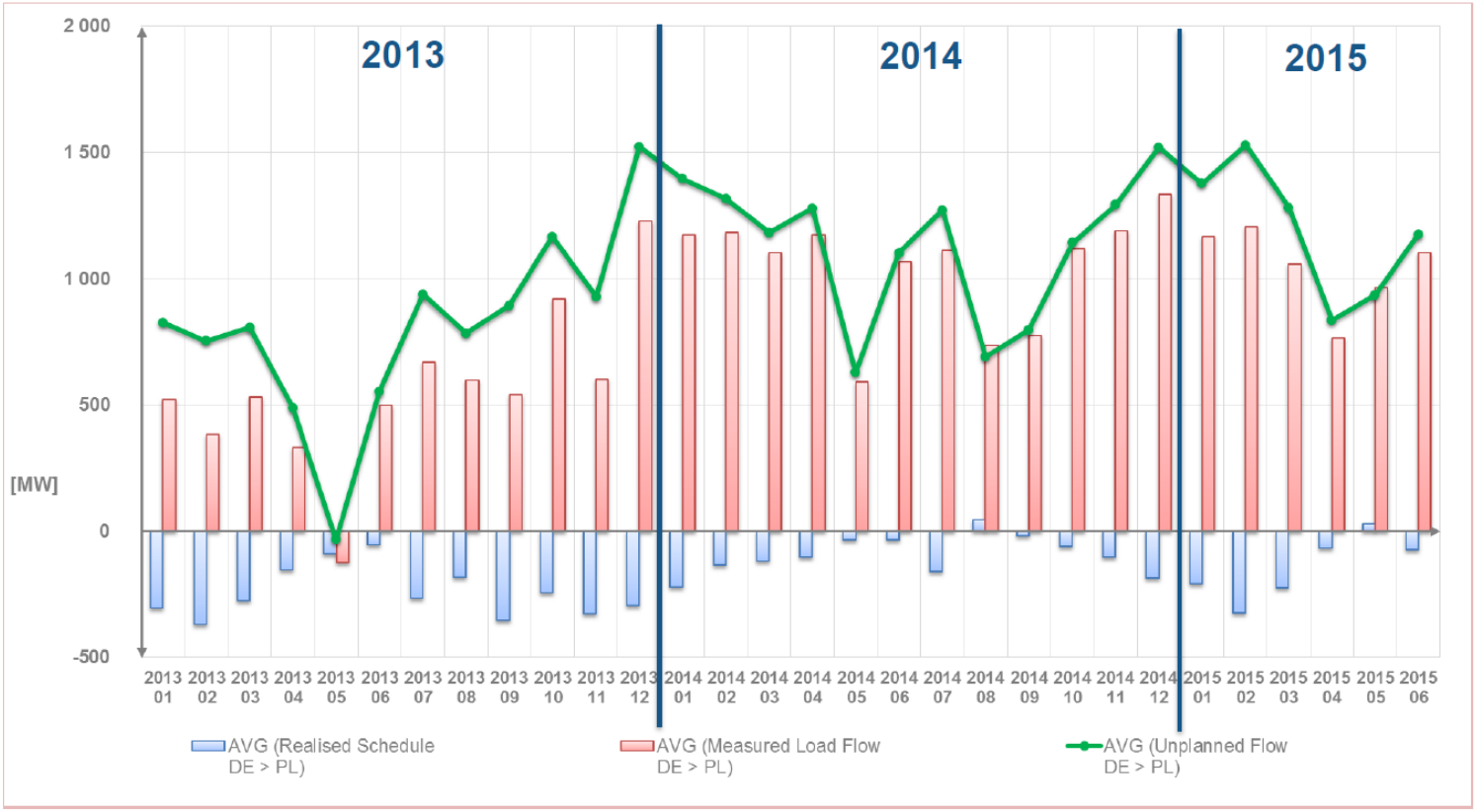
How long current AS mechanism has been used?
Source: EURELECTRIC

EXAMPLE:
Germany – Poland cross border exchange

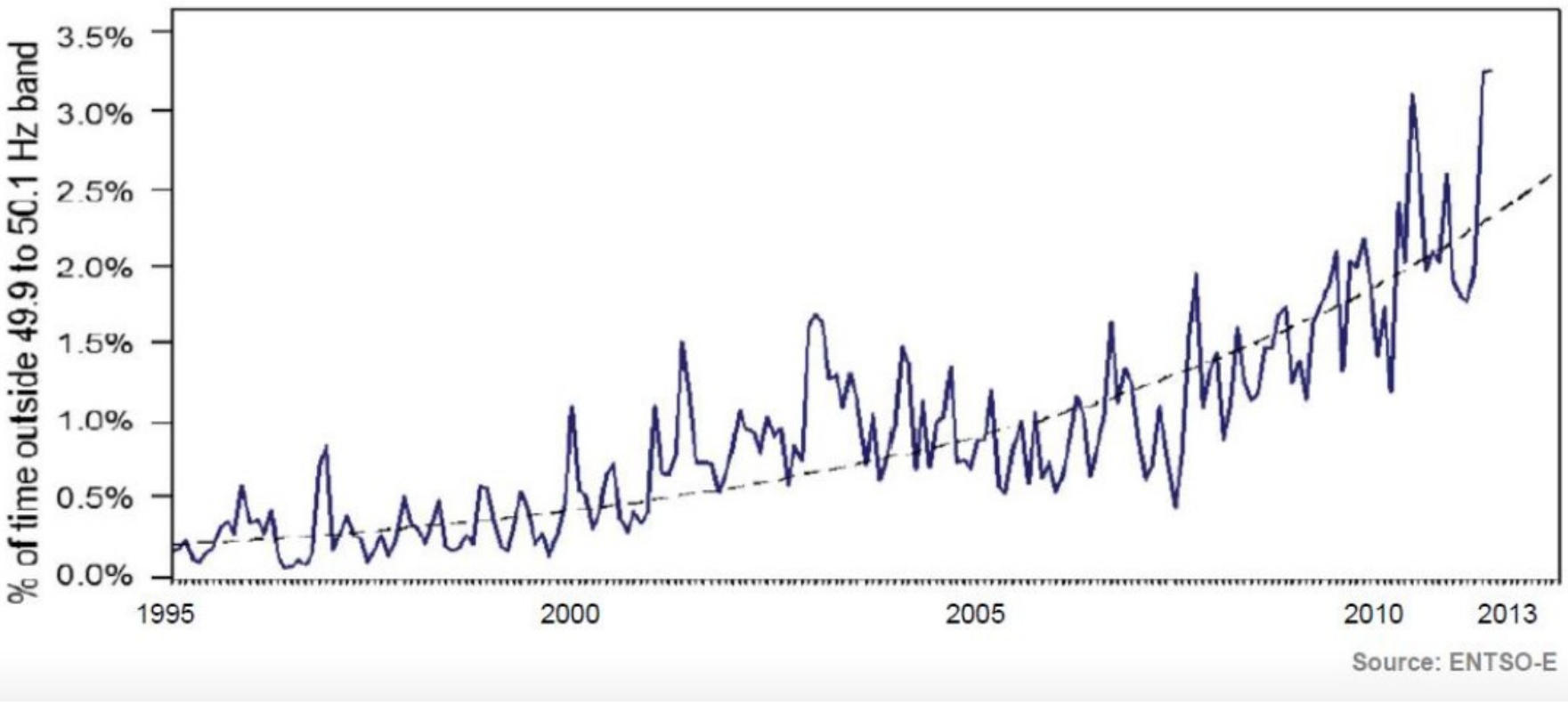
Challenges of large scale integration of intermittent generation:
UNPLANNED LOOP FLOWS

EXAMPLE:
Germany – Poland cross border exchange

Unplanned flows



EVOLUTION OF FREQUENCY DEVIATIONS IN ENTSO-E



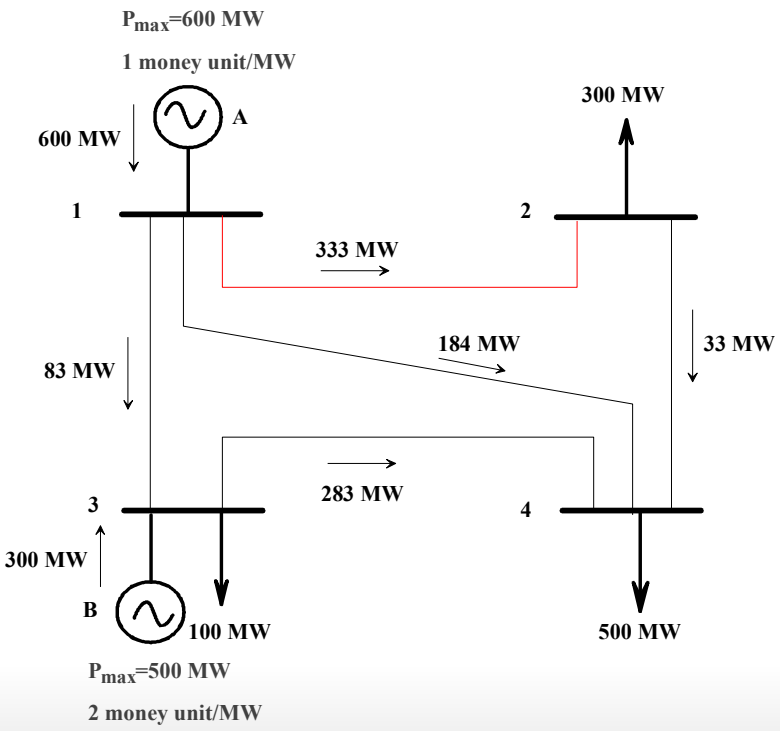
Note: 2.5% of a time per year = 219 hours > 9 days !

#4 NETWORK PLANNING

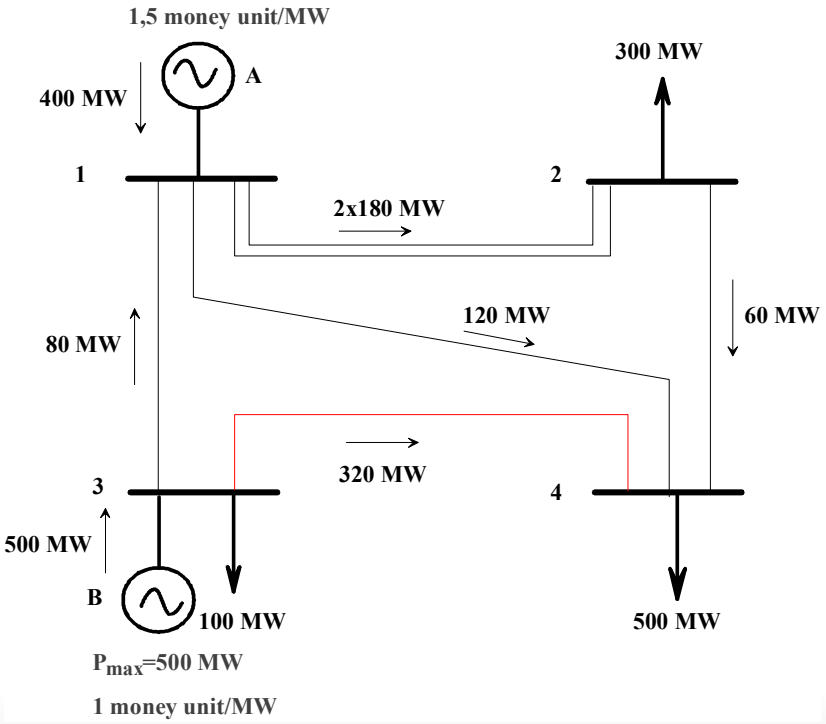
EXAMPLE:
Network planning uncertainties

BASE CASE – overloading of the line 1-2

(transmission capacity of all lines 300 MW)



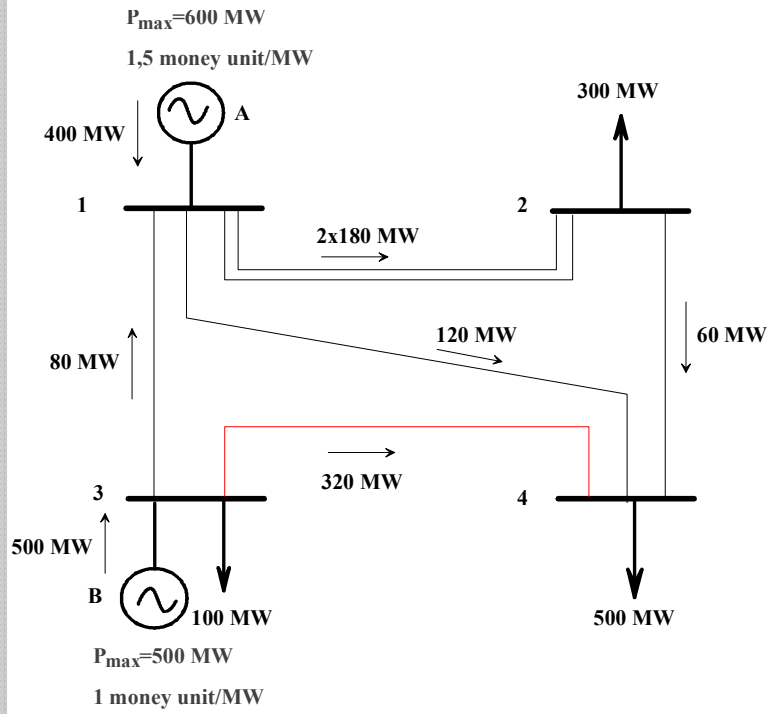
CASE 1 – different generators bidding behavior



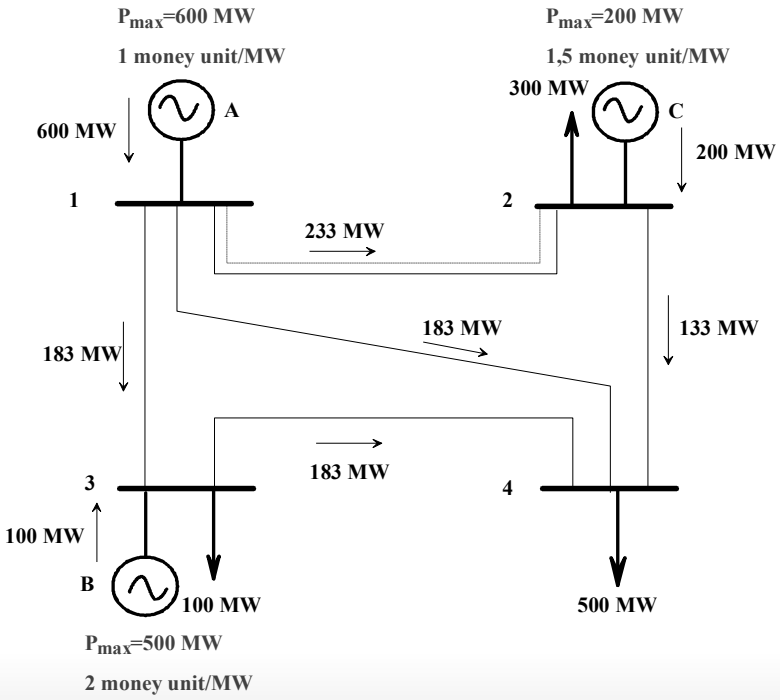
CASE 1 RESULT: TWO network investments needed

EXAMPLE:
Network planning uncertainties

CASE 1 – different generators bidding behavior



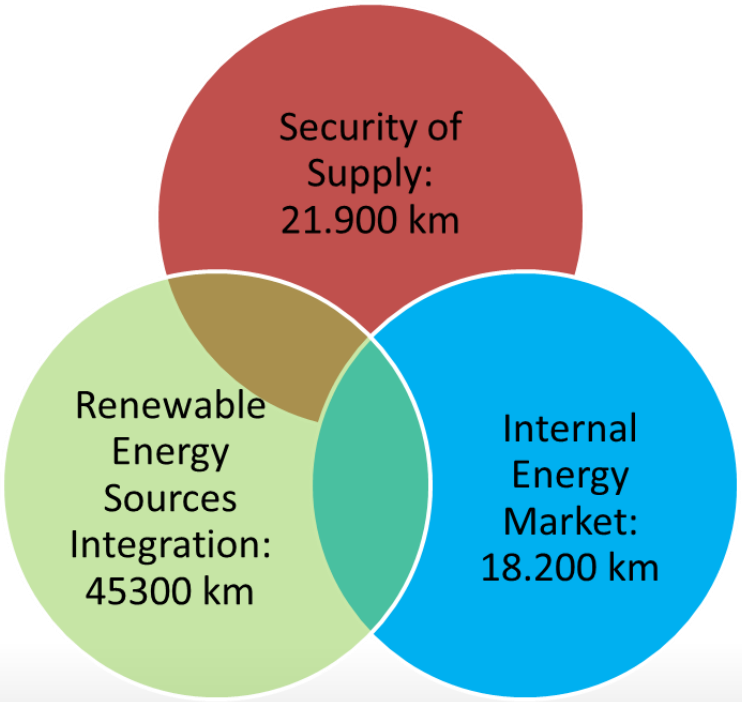
CASE 2 – new generator in the node 2



CASE 2 RESULT : NO network investments needed

ENTSO-E 10-YEARS DEVELOPMENT PLAN

ENTSO-e: 150 billion EUR & 52 300 km lines in next 10 years
(87% (45 300 km) related to RES)



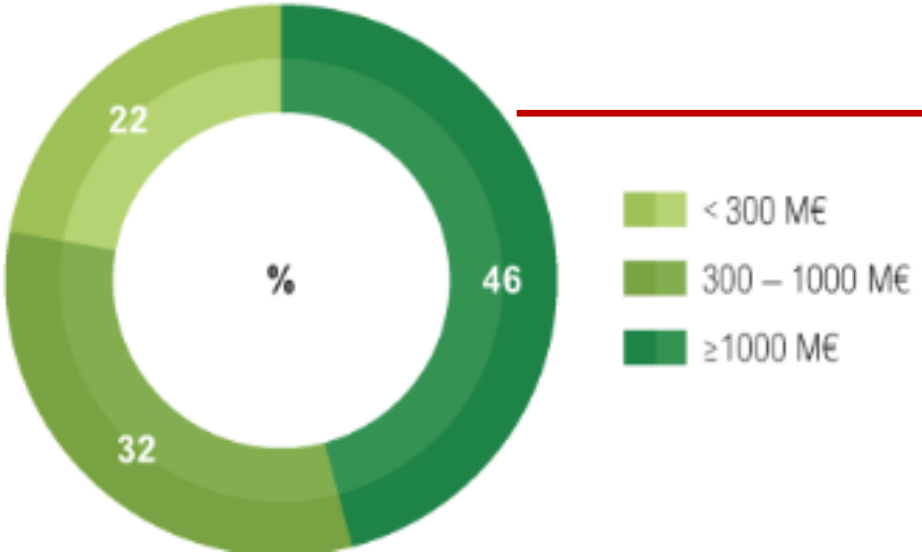
Investment cost breakdown (bil.€)

AT	1.9	IE	2.0
BA	0.1	IS	0.0[30]
BE	2.0-4.0	IT	5.9
BG	0.3	LT	0.7
CH	1.6	LU	0.2
CY	0.0	LV	0.4
CZ	1.5	ME	0.1
DE	34.8-54.2	MK	0.1
DK	3.7	NI	0.5
EE	0.2	NL	3.3
ES	4.3	NO	7.9
FI	0.8	PL	1.9
FR	8.4	PT	0.7
GB	15.9-16.2	RO	0.5
GR	2.6	RS	0.4
HR	0.2	SE	3.6
HU	0.1	SI	0.6
		SK	0.3
Total	110-150		

Source: ENTSO-e

WHY IS COORDINATED NETWORK PLANNING IMPORTANT ?

ENTSO-E 10-YEAR DEVELOPMENT PLAN



Source: ENTSO-E

46 % of the projects display costs greater than 1 bil.€

NO MISTAKES ALLOWED !

€150bn
investments, of which 70-80 by 2030

1 to 2 €/MWh
impact on bills due to transmission investment

45 to 60%
RES across 4 Visions for 2030

50% to 80%
emissions cut depending on the vision

1.5 to 5 €/MWh
potential reduction in wholesale prices

40%
reduction in congestion hours

NETWORK PLANNING UNCERTAINTIES

1. New power plants size and locations
2. Load growth
3. RES integration
4. Future market transactions
5. Unknown generators dispatch
6. Electricity market price

WHAT ABOUT FUTURE ?