SMAGRINET
POWERING SMART GRID
EXPERTISE IN EUROPE

MODULE: Economic operation and societal changes

25.11.2020/Train-the-trainers day

Karl Kull from TalTech

Belonging: **DEPARTMENT OF ELECTRICAL POWER ENGINEERING AND MECHATRONICS**

ENERGY ECONOMICS AND HIGH VOLTAGE ENGINEERING RESEARCH GROUP

TEACH:

- Distributed Generation in Digitalised Power Systems;
- Economics of Power Systems;
- Wood fuel resources and production technologies

Setup for the course

Modules and lectures have to be integrated and coordinated with several levels of management.

This takes time: **6-12 months**

Our solution for the piloting phase:
Integrated the material into an existing course :

- Economics of Power Systems
- **Distributed Generation in Digitalised Power Systems**

Solution for next year:

Inital round:

1. 23 first year MA students.
2. Engineering BA background.
3. Rather lacking of economic and political notions during their BA.
4. Do not read newspapers, sector specific legislation or follow twitter or social media channels of EU and Power industry leaders.
5. A blanc canvas.

Application of their skills after graduation

- Project management and grid planning vocation at TSOs or DSOs.
- Work in the public sector – ministry level analysts and specialists.
- Construction companies.
- Form their own energy and power related companies

Emphasised content and what to look for in these modules

I. Energy Policy (28 slides)

1. Energy policy areas
2. EU Energy Strategy
3. Clean Energy Package
4. Future challenges

EU aims 2020-2030

Greenhouse Gas Emissions

2020	2030
-20%	≥-40%

Renewable Energy

2020	2030
20%	≥32%

Energy Efficiency

2020	2030
20%	≥32.5%

Climate in EU-funded programmes 2014-2020

2020	2030
20%	25%

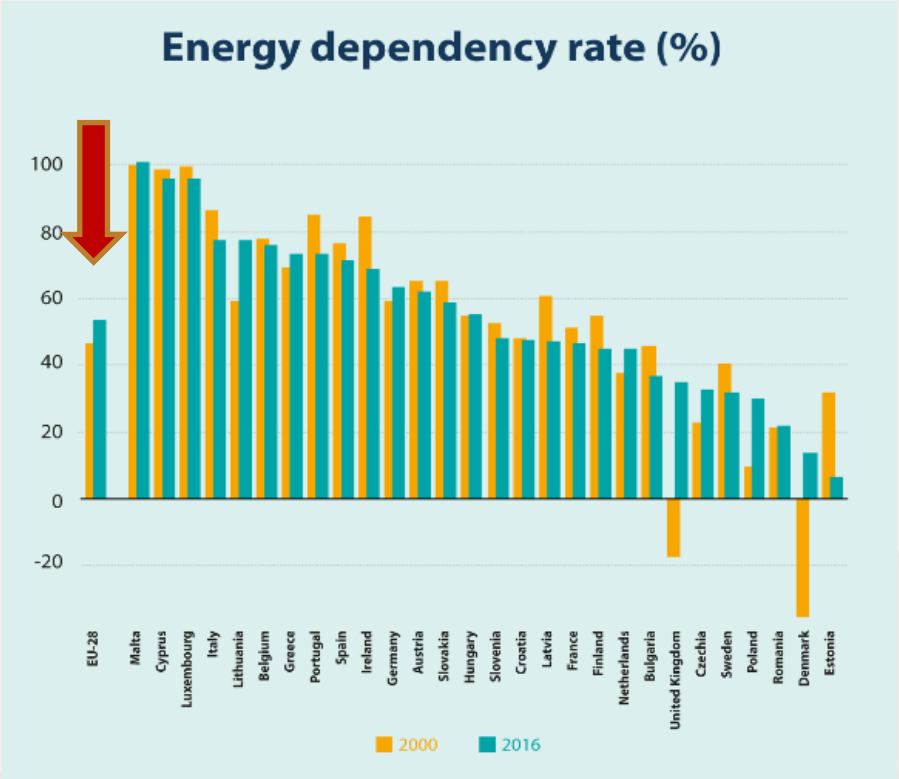
Interconnection

2020	2030
10%	15%

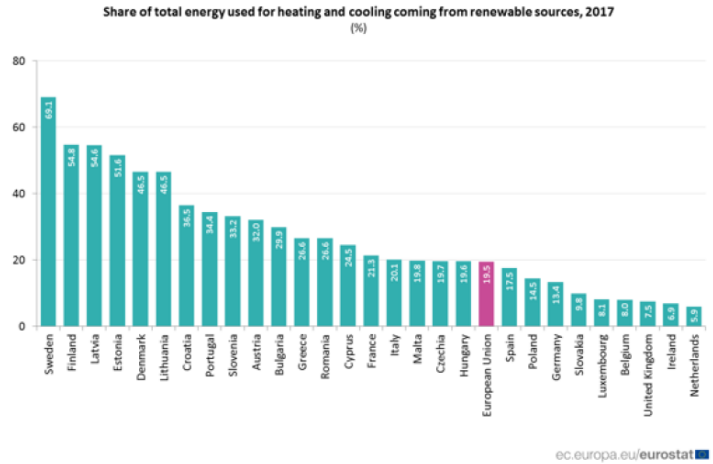
CO2 from :

Cars	Vans	Lorries
2030		
-37.5%	-31%	-30%

Energy import in 2000 and 2016 – Increasing!



EU RES statistics by country



In 4 EU Member States, more than half of the total energy used for heating and cooling came from renewable energy sources in 2017:

- Sweden (69.1 %)
- Finland (54.8 %)
- Latvia (54.6 %)
- Estonia (51.6 %)

In contrast, the lowest shares were in:

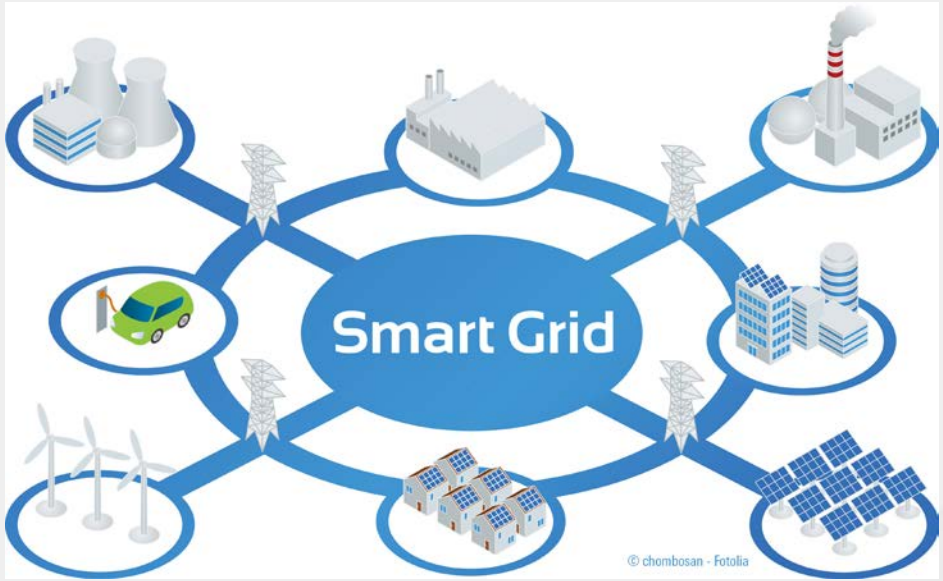
- the Netherlands (5.9 %)
- Ireland (6.9 %)
- the United Kingdom (7.5 %)

- Let then know where they/your country is compared to the EU
- What do they expect or predict if they see the information.
- What should the country do now? How does it compare on what is actually being done?

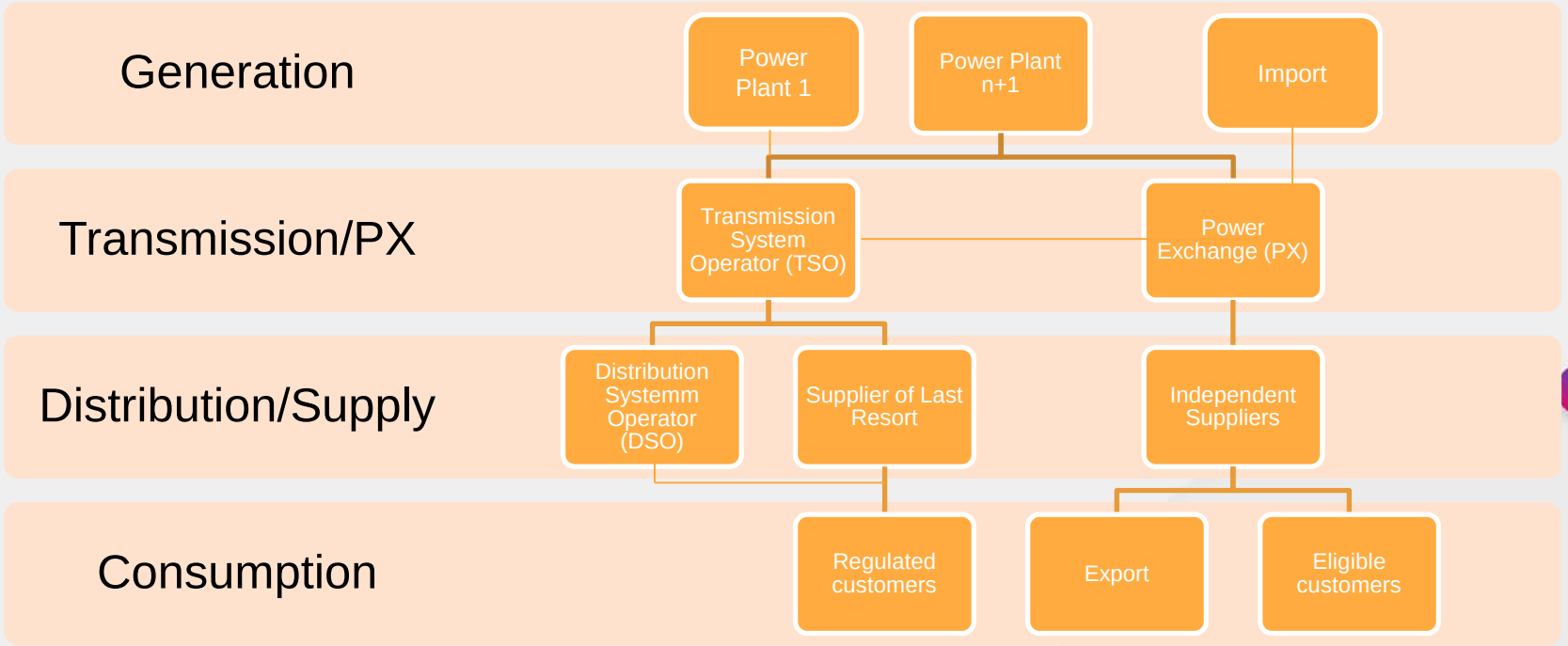
POWER SECTOR REGULATION. ELECTRICITY PRICES

1. Market models
2. Market organization
3. Price regulation
4. Regulation methods
5. Regulation and long-term planning

The changing structure of the electrical system

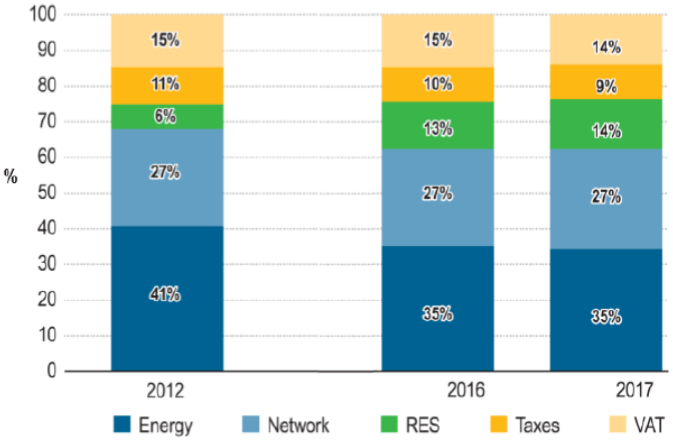


Classical EU market structure - decentralised

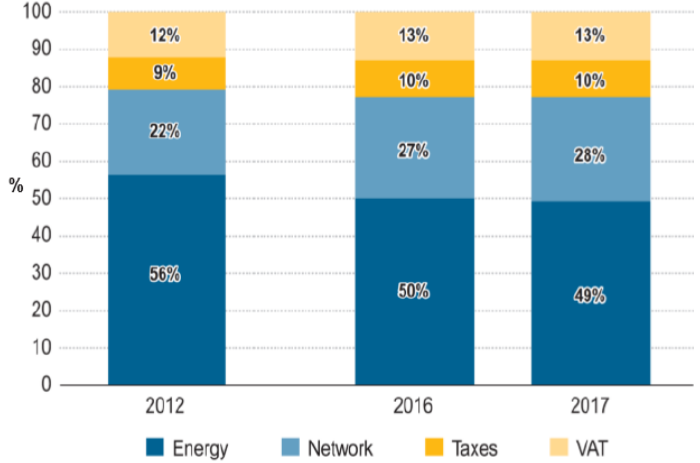


Example. Energy price structure in EU

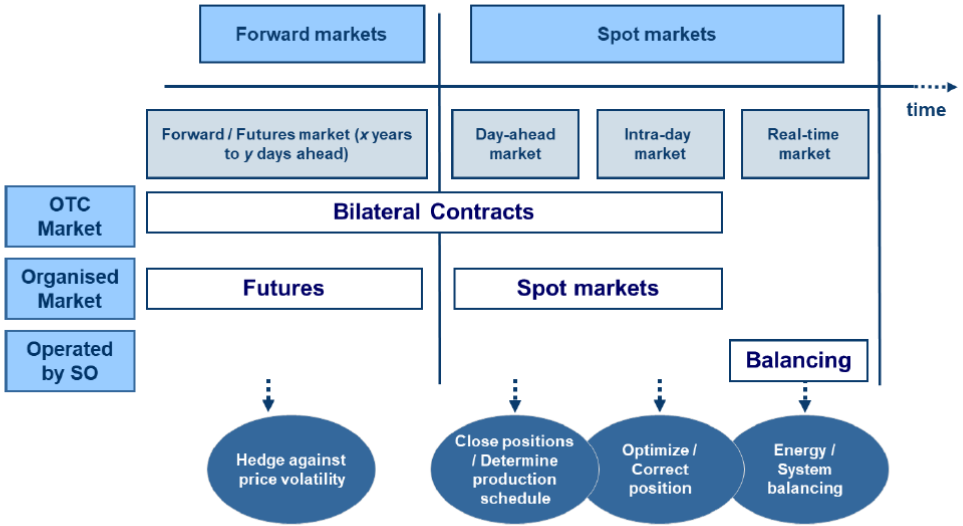
Electricity retail price breakdown (2012 - 2017)



Gas retail price breakdown (2012 - 2017)



Market organization



- How do you provide stability for a company?
- What are the diferent risks of being volatile
- The understanding of „end price“ and how it is formed (grid tariff, electricity price etc.)
- How markets work – they shall know how to buy or operate in the energy market.
- What will happen to the price if?

CONTENT

1. Some history of energy policy
2. Institutions and reglementation
3. Creation of EU electricity market
4. What to regulate?
5. Future challenges

Single market!

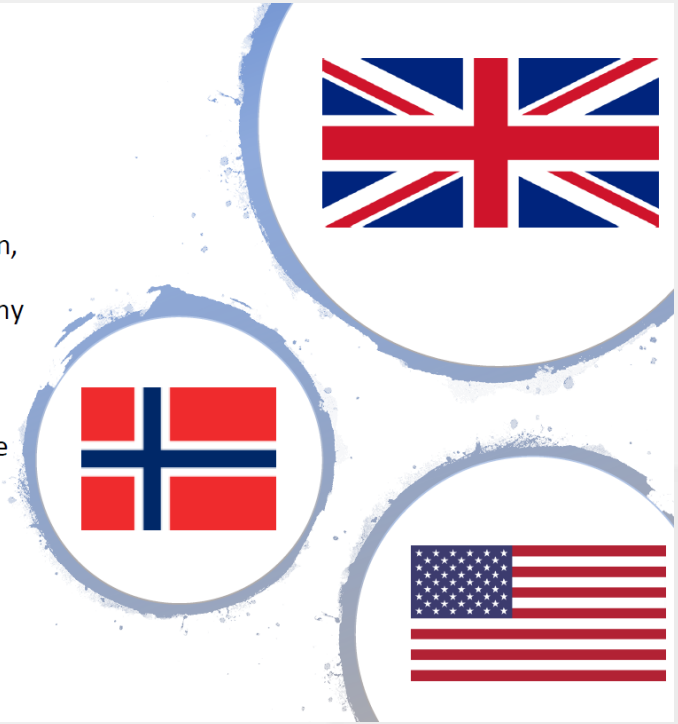
Free movement

- In **1987** it was presented **the European Single Market Program**, which has the objective for the member countries to remove any physical, legal and financial obstacles to free movement of:
  - **Goods**
  - **Services**
  - **Capital**
  - **Labor** within the European Union
- In addition, the Single European Act requires the annulment of the State-Owned monopolies
- This requirement is also applied to the electricity sector

Where does it all come from?

Pioneering

- In **1990 Great Britain** made a good start in the electricity sector restructuring and privatization, and demonstrated that the unbundling and wholesale electricity market is possible, so many countries have also chosen the path of reform, as **Norway – in 1991**
- After the adoption of the Energy Policy Act, the **United States** began liberalization in the electricity sector **in 1992**
- Each EU country went its **own reform path**, as the electricity market structure, trading rules, market opening dates were different, respectively and prices varied



Liberalisation

- The level of **declared and real** market opening is the first criterion, indicating the situation of electricity market
- In older countries of **EU - 15** the electricity market opening was about 60 % of energy sold in 1999 and 90 % – in 2004
- For example, the Swedish market was **fully opened** in 1996, Finland - in 1997, Austria - in 2001, and Denmark, as in Belgium and Spain, - in 2003
- 2nd Electricity Directive's deadline - 1st July 2007; **EU - 27 and Norway** declared the electricity market liberalised 100 %, except:
  - Cyprus (31 %)
  - Italy (80 %, but 100 % expected in 2008)
  - Luxembourg (84 %)
  - Estonia (13 % - consumers with a consumption of 40 GWh/year, and 100 % - in 2013)

Objectives

Important international cooperation among regulators, market participants and customers, ensuring:

- Energy affordability
- Competitiveness of industry
- Investment's attraction
- Sustainable development of infrastructure and rational usage of energy resources

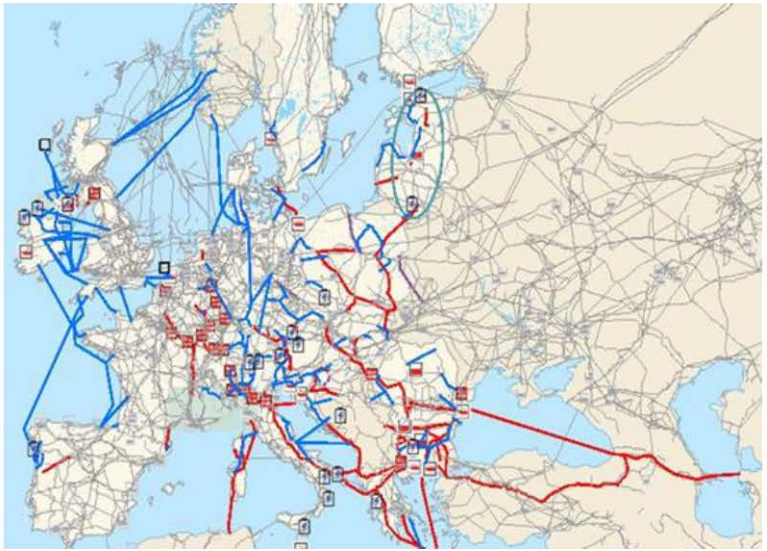
European Commission

ACER
Agency for the Cooperation of Energy Regulators

CEER
Council of European Energy Regulators

entsoe

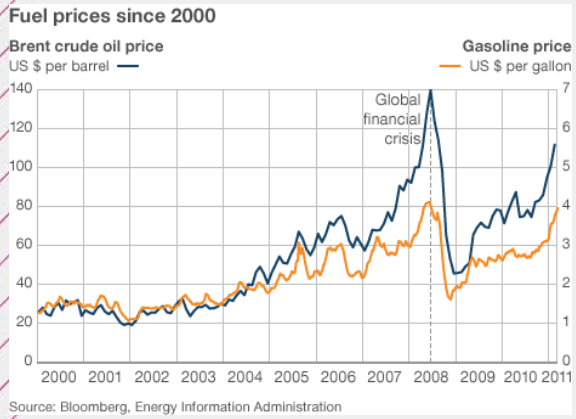
Investments – first important step



- In 2010 EU Ten-Year Network Development Plan (TYNDP) prepared – **700 billion EUR till 2020**
- **Projects of Common Interest** (PCI) – approved list of projects in each region
- Reasons:
  - **Supply safety**
  - **EU market creation**
  - **RES integration**
- Long-term financing based on **Cost-Benefit Analysis** (CBA) - EU Regulation No. 347/2013

Note: EU has 28 member-states, and 43 TSOs from 36 countries are members of ENTSO-E (the European Network of Transmission System Operators for Electricity)

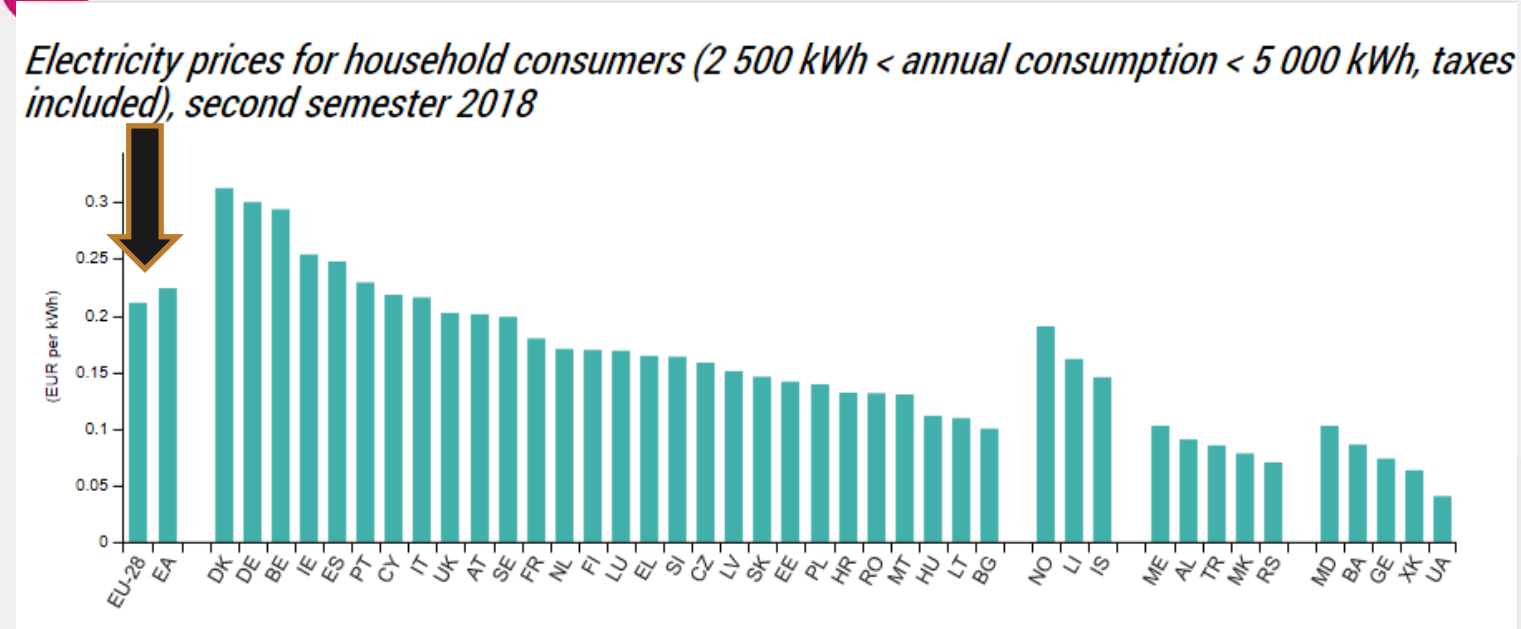
Energy prices are priority on the table of Governments, Parliaments and the European Commission



CONTENT

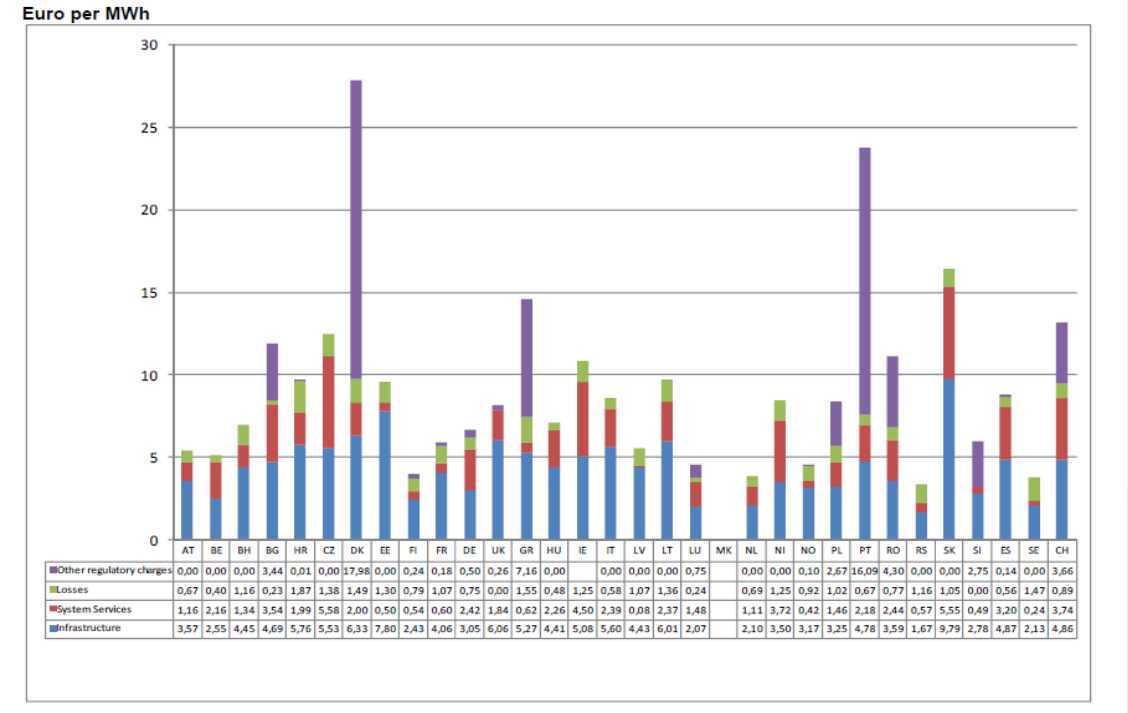
1. Electricity price structure
2. Revenue calculation
3. Price differentiation
4. End-user price

Electricity price for households



Source: Eurostat

Transmission price structure in EU

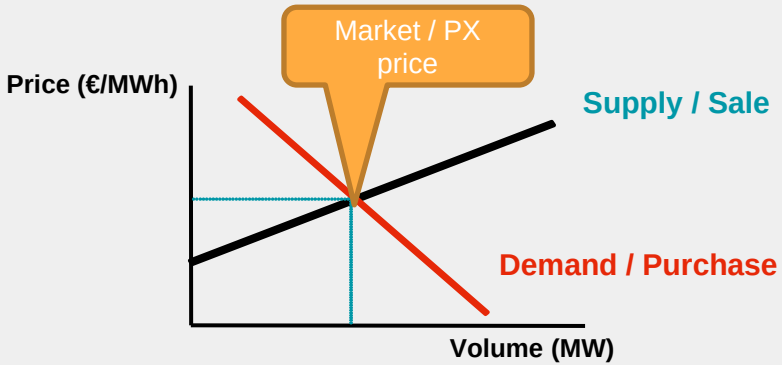


	AT	BE	BH	BG	HR	CZ	DK	EE	FI	FR	DE	UK	GR	HU	IE	IT	LV	LT	LU	MK	NL	NI	NO	PL	PT	RO	RS	SK	SI	ES	SE	CH
Other regulatory charges	0,00	0,00	0,00	3,44	0,01	0,00	17,98	0,00	0,24	0,18	0,50	0,26	7,16	0,00		0,00	0,00	0,00	0,75		0,00	0,00	0,10	2,67	16,09	4,30	0,00	0,00	2,75	0,14	0,00	3,66
Losses	0,67	0,40	1,16	0,23	1,87	1,38	1,49	1,30	0,79	1,07	0,75	0,00	1,55	0,48	1,25	0,58	1,07	1,36	0,24		0,69	1,25	0,92	1,02	0,67	0,77	1,16	1,05	0,00	0,56	1,47	0,89
System Services	1,16	2,16	1,34	3,54	1,99	5,58	2,00	0,50	0,54	0,60	2,42	1,84	0,62	2,26	4,50	2,39	0,08	2,37	1,48		1,11	3,72	0,42	1,46	2,18	2,44	0,57	5,55	0,49	3,20	0,24	3,74
Infrastructure	3,57	2,55	4,45	4,69	5,76	5,53	6,33	7,80	2,43	4,06	3,05	6,06	5,27	4,41	5,08	5,60	4,43	6,01	2,07		2,10	3,50	3,17	3,25	4,78	3,59	1,67	9,79	2,78	4,87	2,13	4,86

Source: annually updated ENTSO-E Overview of transmission tariffs in Europe: Synthesis

Perfect competition and a real market

- According to economic theory, in perfectly competitive markets prices should be equal to maximum cost:



- In practice, however, prices in energy markets are sometimes much higher…

Importan things to know!

- RR –RevenueRequirement
- OPEX –OperationalExpenses/Cost;
- O&M –Operation and Maintenance
- CAPEX –CapitalExpences/Cost
- WACC –Weighted Average Cost of Capital
- RAB –Regulated Asset Base
- ROI –Returnon Investment

Make sure to emphasise and make sure they understand this!

- Again – show them where your country sits in the EU context
- What should be done?
- What would happen?

CONTENT

1. Energy balance
2. Essence of forecasting
3. Collection of initial information
4. Classification of energy demand forecasting methods
5. Time-series methods
6. Econometric methods
7. Simulation methods

- Information collection:
  - Local weather databases
  - Local Energy statistics
  - Government reports

TIME SERIES ANALYSIS (1)

Time series analysis let us to identify their characteristic features:

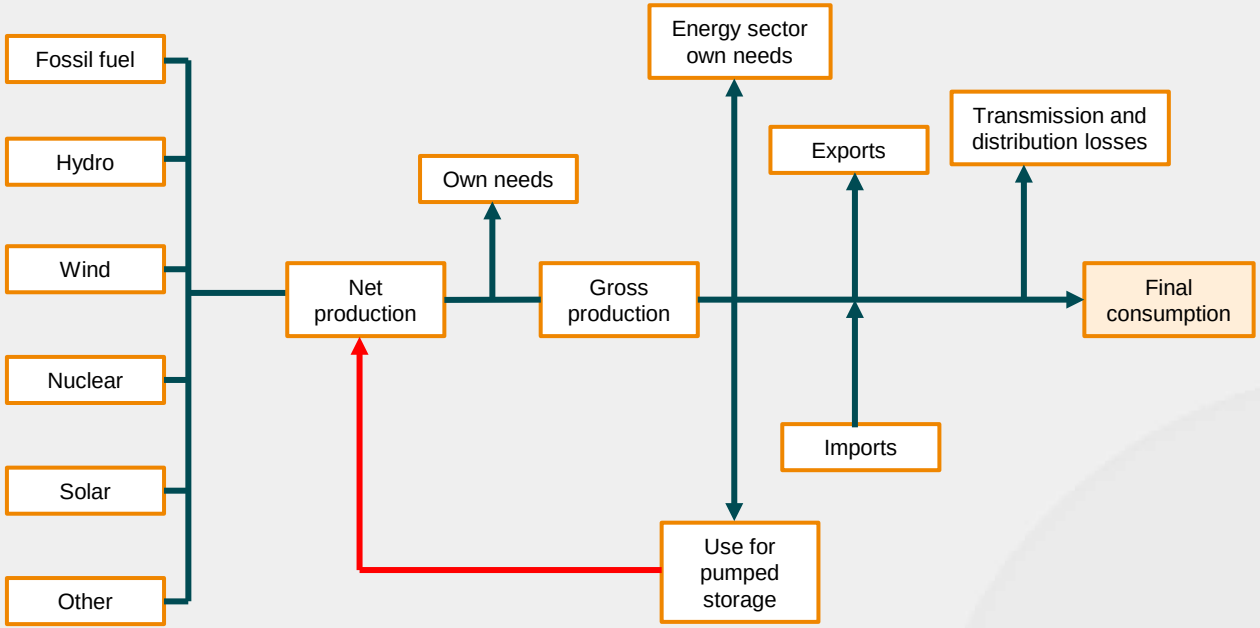
- changes leading to a certain **overall trend** of the process (growth, decline or stability),
- **cyclical fluctuations**, most often driven by economic cycles (crises, periods of rapid growth, etc.),
- **seasonal fluctuations**, that repeat at the same time each year (daily variations in electricity load curve),
- **irregular fluctuations**, that are difficult to analyze (they may be caused by wars, natural disasters, numerous random causes, etc.).

- Cause and effect relationships
- Find and analyse the random component – try to define it.

$$Y = F(X) + \varepsilon$$

ELECTRICITY BALANCE

Electricity balance is one of the most important components of the energy balance.



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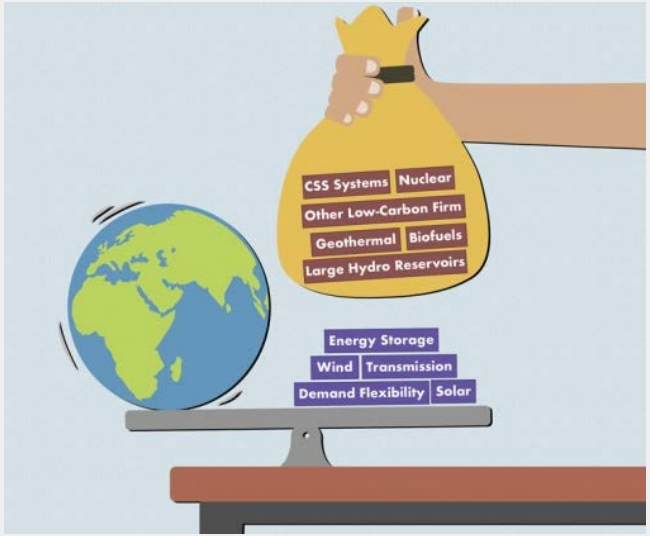


Financial side of:

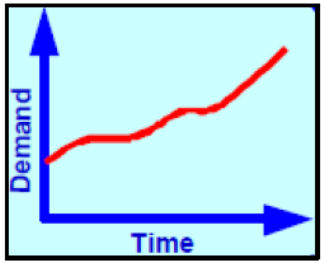
1. Energy sector planning
2. Creating of planning database
3. Integrated financial analysis
4. Characteristics of energy sector development models
5. Power sector planning
6. Peculiarities of generation planning

- SCALE OF THE PLAN
- TIME HORIZON
- LEVEL OF DETAIL

ELECTRICITY DEMAND FORECAST

The electricity demand forecast must include:

- Energy demand, kWh
- Load time schedule
- Power demand, kW



The two main types of **uncertainty** cause the electricity demand:

- The estimated size of demand may be either too low or too high;
- Random nature of load (for example, due to climatic conditions).

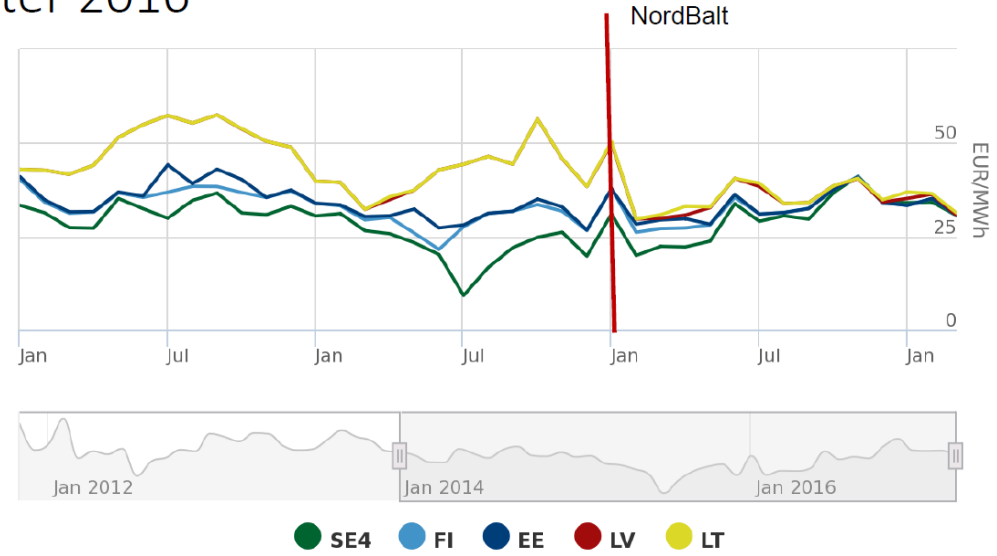
CONTENT

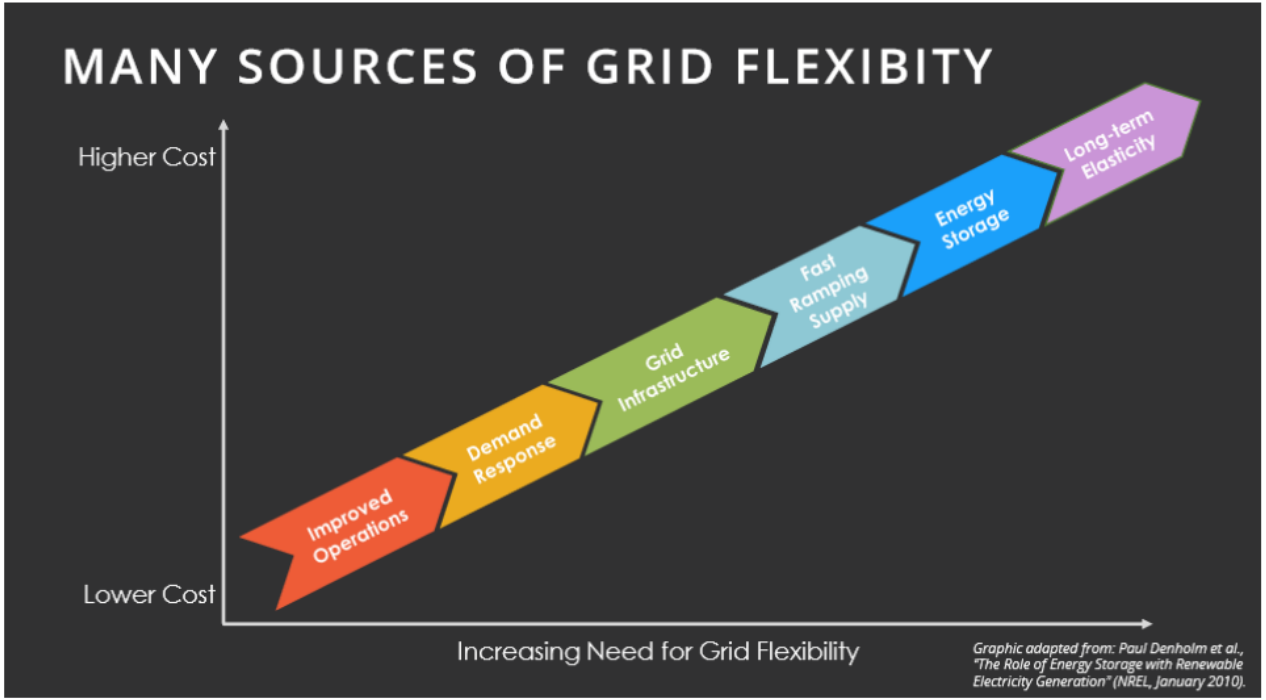
1. Legal aspects of the smart grid
2. Forward market
3. EU situation
4. Issues and solutions

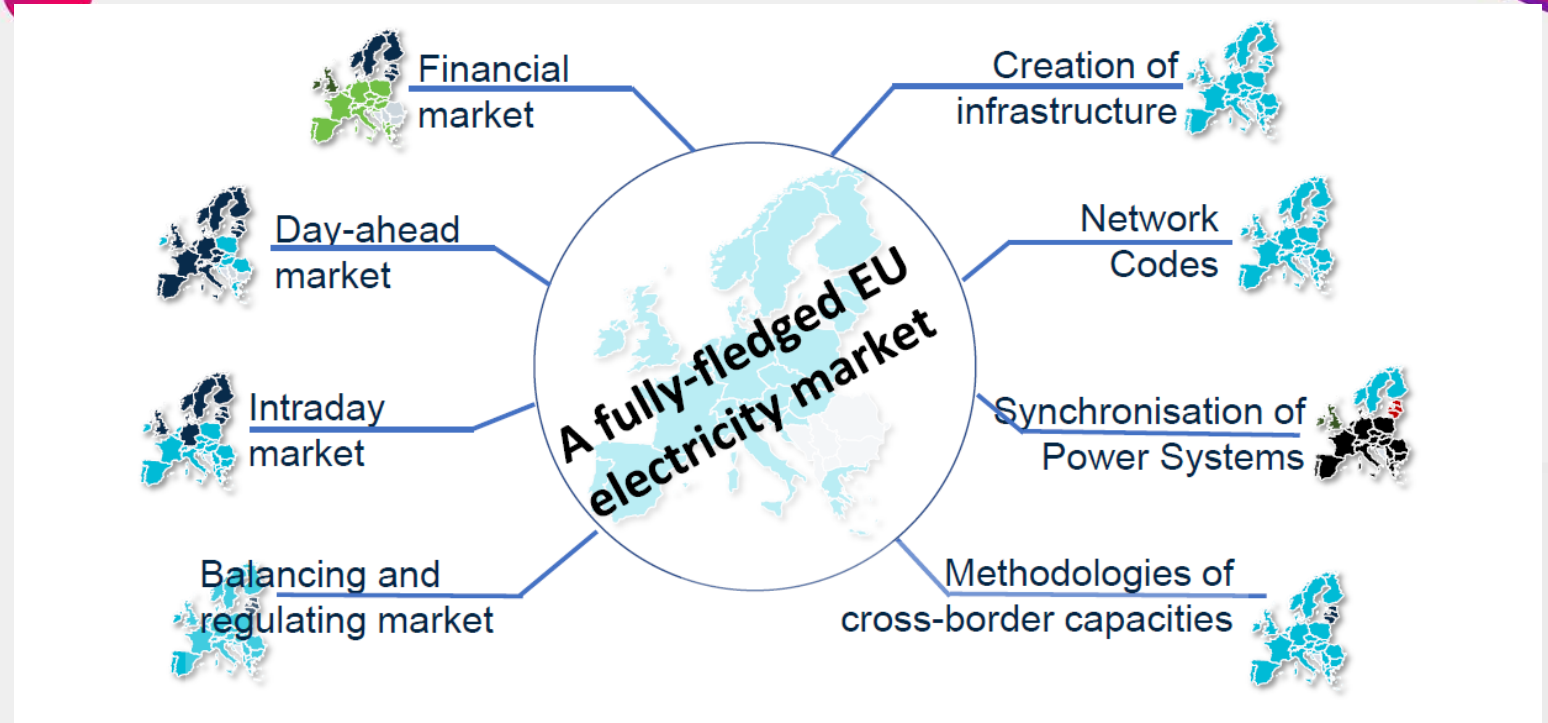
- The **Guideline on Capacity Allocation and Congestion Management (CACM)** sets out the methods for calculating how much space can market participants use on cross border lines without endangering system security

- CACM is the **cornerstone of a European single market** for electricity

Example. New interconnections – Baltic region after 2016

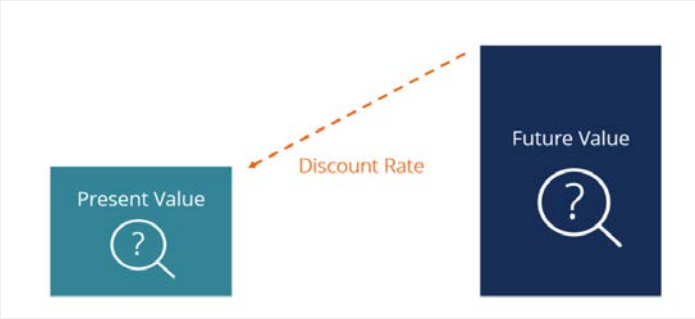



MANY SOURCES OF GRID FLEXIBITY
Higher Cost
Lower Cost
Increasing Need for Grid Flexibility
Improved Operations
Demand Response
Grid Infrastructure
Fast Ramping Supply
Energy Storage
Long-term Elasticity
Graphic adapted from: Paul Denholm et al., "The Role of Energy Storage with Renewable Electricity Generation" (NREL, January 2010).


Financial market
Day-ahead market
Intraday market
Balancing and regulating market
A fully-fledged EU electricity market
Creation of infrastructure
Network Codes
Synchronisation of Power Systems
Methodologies of cross-border capacities

- Outcome: why some technologies are in the market and why some are not
- Why we need to interconnect?
- What will happen to the electricicty price? What will happen to the end price?

CONTENT



1. Time value of money. Discount rate
2. Methods of project economic evaluation
3. Cost-effectiveness analysis
4. Levelized cost of electricity production
5. Risk classification and management
6. Sensitivity analysis
7. Risk assessment

This method considers the difference between **the total discounted benefits** minus **the total discounted costs**, which gives **the Net Present Value of a project**:

$$NPV = PVB - PVC$$

Format of the exercises

- Cost-benefit analysis of

  A specific type of powerpland/energy unit

  The cost-benefit analysis of a micro-grid feasibility. Comparison with the general energy tariff.

- Similar to ULOR eperience the lack of pre-existing knowledge was a concern but with the help of pushing them towards news and relevant information helped them grasp the information better.
- The tools that they created with the cost benefit are being used in ohter subjects as well
- Tariffs and formation of tariffs was the hardest part for students

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