ELEC0018-1 Energy Markets

Lecture 6: Impact of transmission

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Menu for today

1. Reminder: locational marginal prices, merchandising surplus
2. Role of TSOs, ENTSO-E, RSCs
3. Transmission rights
4. Losses

Introduction

Transmission constraints and losses can introduce gross distortions in the market for electrical energy.

In this lesson: we study the effects that a transmission network has on trading of electrical energy and the special techniques that can be used to hedge against these limitations.

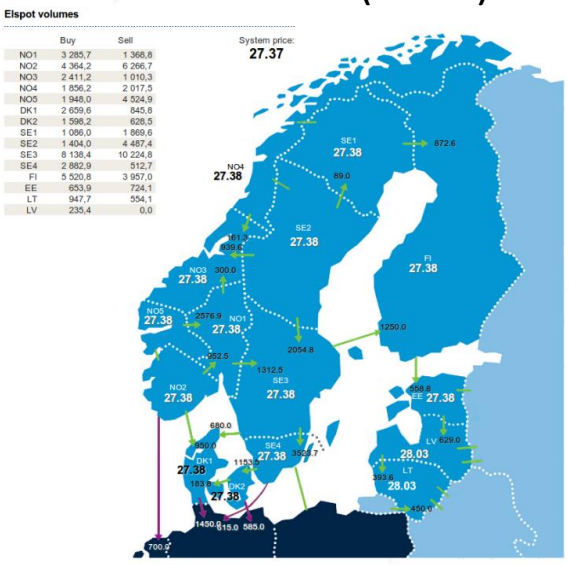
Source: [Kirschen]

Reminder

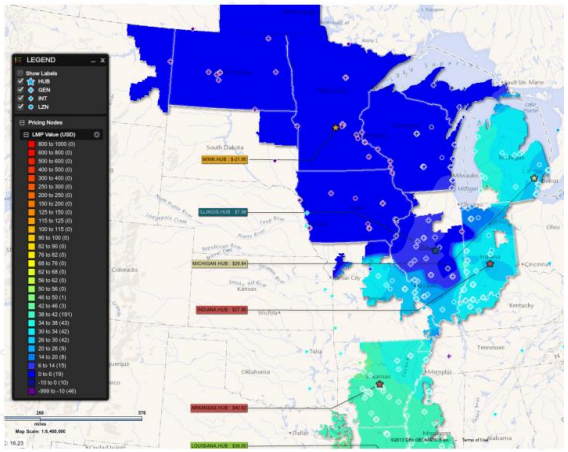
Locational marginal prices (i.e. *nodal* or *zonal* prices) = price applied to all consumers and producers at the same node/zone.

Locational marginal prices are usually higher in areas that normally import power and lower in areas that export power.

Scandinavia (zonal)



Midwest(nodal)



Source: [Pinson], http://nordpoolgroup.com, https://www.misoenergy.org

Reminder

Merchandising or congestion surplus : difference between the payments made by the loads and the revenues of the generator.

Congestion surplus only arises when the transmission line is saturated/congested.

Reminder - Actors

TSO: Transmission System Operator (ISO owning the transmission system)

ENTSO-E: European Network of TSOs for Electricity

What are their role ?

50hertz, ΑΔΜΗΕ, amprion, APG, ČEPS, elia, ENERGINET, FINGRID, nationalgrid, RED ELÉCTRICA DE ESPAÑA, REN, Rte, Statnett, SVENSKA KRAFTNÄT, swissgrid, TenneT, TRANSNET BW, Terna Rete Italia

Roles of TSOs

Security of supply in a certain geographical zone that is called a **control area** (can be a country or smaller).

Plan years ahead how the grid will evolve (**TYNDP**)

5 to 10 years in advance: assess whether system is fit to cover demand always (System Adequacy Assessment at national and European level - ERAA)

From a year in advance to real time: run a continuous series of calculations and adapt their assumptions constantly to new issues arising on their grid but also that of their neighbours.

Taking decisions within seconds when something happens that endangers security of supply

If despite their efforts, there is an incident, it is easy to trace back where the problem came from, fix it and give compensation to the affected grid users.

Source: https://www.entsoe.eu/regions/

Roles of ENTSO-E

The multilateral agreement and system operation guideline give ENTSO-E the role to support the TSOs and their regional strategy.

They do so by

- providing IT tools and systems such as the **common grid model** which allow TSOs to improve their operational planning at regional and pan European level
- but also, by communication on the **RSCs** and the TSOs roles.

Source: https://www.entsoe.eu/regions/

Roles of RSCs
- Regional Security Coordinators

Created because of the willingness to better coordinate and share information

Independent from individual national and from TSOs interests.

Intervene one year ahead to one hour before dispatch

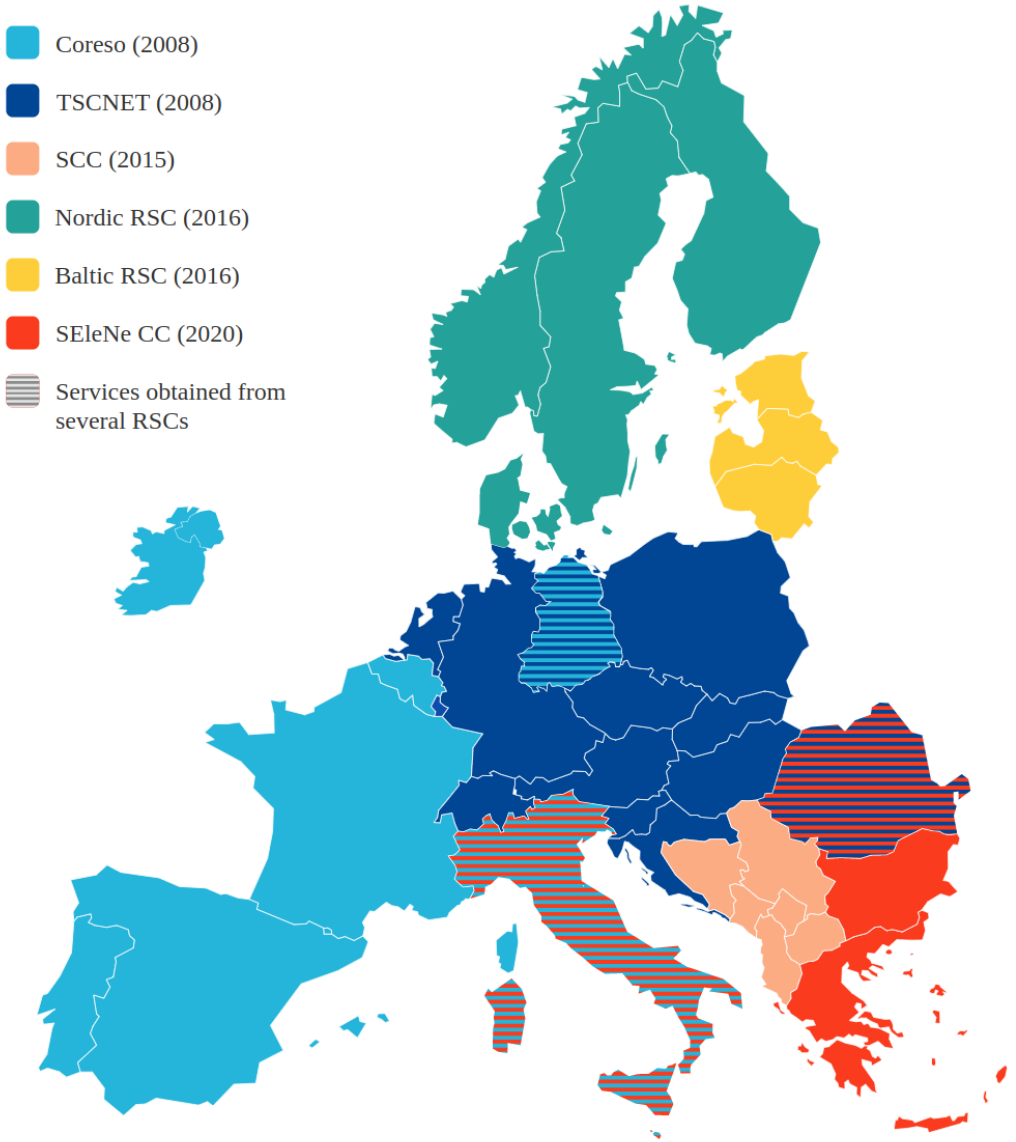
Run calculations and make recommendations to TSOs

Must carry out five services:

- Security analysis,
- capacity calculation,
- outage coordination → to coordinate planned outage due to maintenance (before only done between neighbouring countries),
- adequacy forecast,
- **common grid model**.

Source: https://www.entsoe.eu/regions/

The current RSCs



Source: https://www.entsoe.eu/regions/

The common grid model (CGM)

Each TSO publishes its computer model, which is the dynamic representation of its electricity grid, called an **IGM (Individual Grid Model)**.

RSC engineers receive various IGMs from TSOs. They merge them to create a CGM, representing the electricity grid at European level.

This service can be provided a year, a week, a day in advance or several times a day.

All TSOs have then the same accurate overview of flows on high voltage lines so that they can study behaviour and guarantee security.

The CGM is the basis for most of the RSC processes.

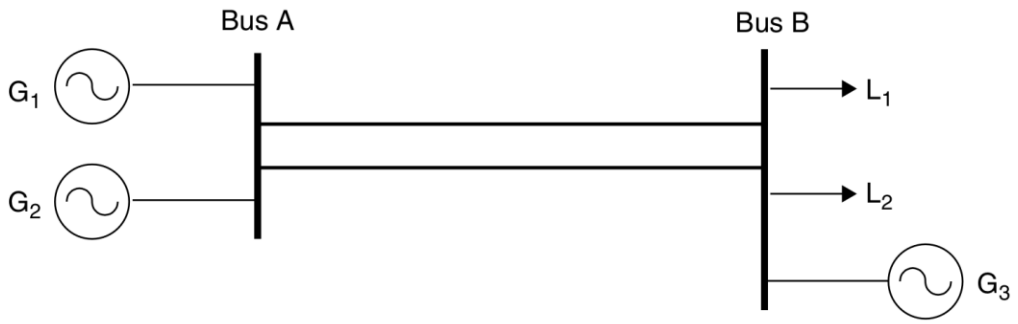
Source: https://www.entsoe.eu/regions/

A simple problem

Problem:

- G1 wants to sell 300 MW to L1
- G2 wants to sell 200 MW to L2.

Is it always possible ?

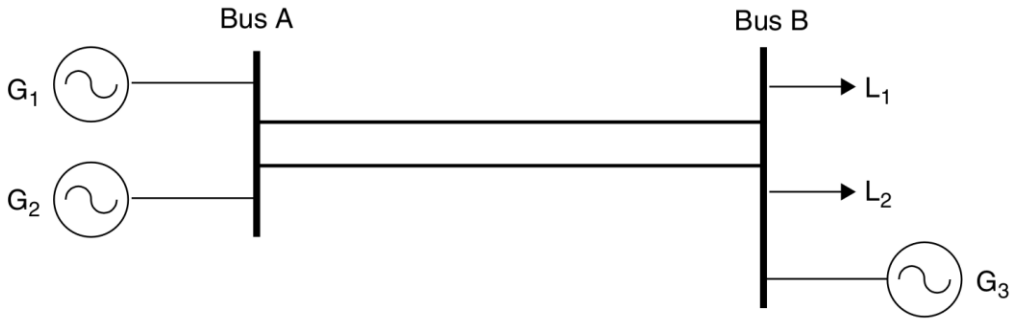


Source: [Kirschen]

Can everyone use the network ?

Problem:

- G1 wants to sell 300 MW to L1
- G2 wants to sell 200 MW to L2.



If transmission lines between Bus A and Bus B are always able to transfer 500 MW, even under contingency conditions: OK.

If transmission < 500 MW: not possible. **Some transactions need to be curtailed**.

Source: [Kirschen]

How to curtail transactions?

Determining whether a set of transactions would make the operation of the system insecure is relatively easy, even if computationally demanding.

But **what about determining which transactions should be curtailed**?

1. Administrative procedures can be established to determine the order in which transactions should be cut back (based on the nature of the transaction, their order of registration or historical data)
2. These administrative curtailments are however **inefficient** and should be avoided because they do not factor in the relative economic benefits of the various transactions that are unknown to the ISO in a decentralized trading system.

Source: [Kirschen]

Physical transmission rights

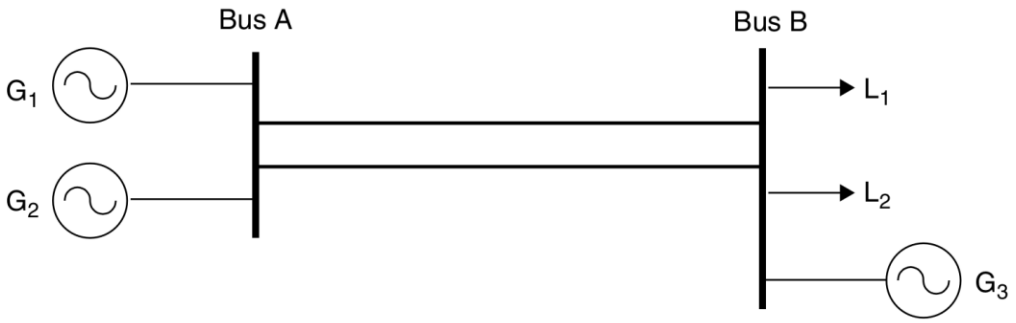
Advocates for decentralized trading believe that buyers and sellers are best placed to decide whether they wish to use the network.

When they sign a contract, buyers and sellers should therefore be offered the possibility to purchase the right to use the transmission system for this transaction.

Physical transmission rights (PTRs) as giving their owner the right to transmit a certain amount of power for a certain time through a given branch of the transmission network.

PTRs are purchased at auctions. Parties can decide whether these additional costs are justifiable.

Source: [Kirschen]



Suppose that:

- G1 and L1 (300 MW) have agreed on a price of 30 €/MWh
- G2 and L2 (200 MW) on a price of 32 €/MWh.
- At the same time, G3 offers energy at 35 €/MWh.

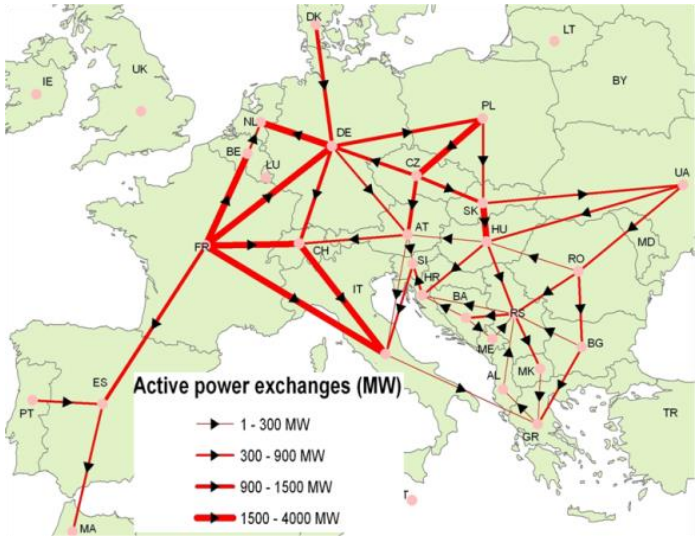
⇒ L2 should not pay more than 3 €/MWh for the transmission rights.
⇒ L1 could pay up to 5 €/MWh before buying energy from G3.

Source: [Kirschen]

Problem with transmission rights

1. In Europe, more complex because more than one line. The path that power takes through a network is not determined by the wishes of market participants but by physical laws. Even if it was determined by the wishes of market participants, issues would still pertain since power can be traded from A to B and B to A (creating counter-flows).

2. Risk of market power

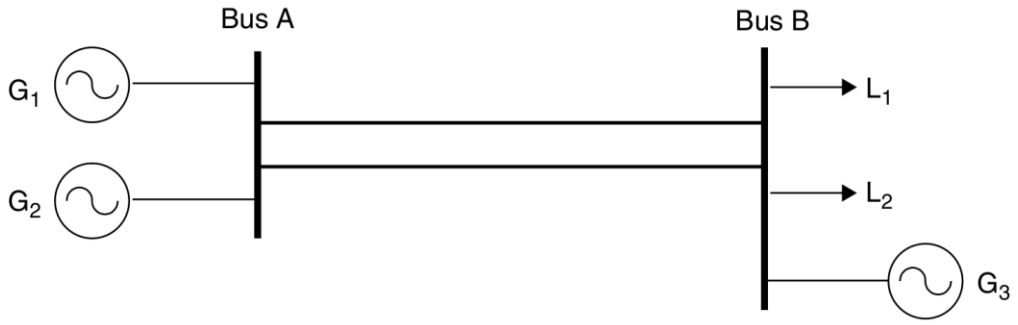


Source: [Kirschen], https://deepresource.wordpress.com/2017/06/05/european-power-grid/

Physical transmission rights and market power

Physical transmission rights can enhance the ability of some participants to exert market power.

Example: The most expensive generator (G3) may want to secure the transmission rights between A and B to fend off competition from generators connected to A.



To avoid this problem, it has been suggested that a "use them or lose them" provision be attached to physical transmission rights.

Source: [Kirschen]

Transmission rights in practice

Historically: right to trade across borders were granted to utilities (state-owned vertically integrated)

In 1996: a directive specifies that TSOs must provide non-discriminatory access to their networks.

Not directly the case because still some long-term contracts in place.

In a market-based environment, two big ways of selling transmission rights:

- Explicit auction
- Implicit auction (a.k.a. market coupling)

Source: [Meeus]

Explicit auction – Periods before day-ahead

An explicit auction means that TSOs auction transmission rights to the highest bidders separately from the trading of energy.

In practice, the auction is done by the intermediary of JAO (Joint Allocation Office), a group of 20 TSOs from 17 countries using harmonized auction rules and timings.

In most of Europe, the cross-border access to forward electricity markets is based on transmission rights and cross-border long-term transmission rights **can only be** allocated through explicit auctions.

Auctions are organised (at least) for monthly and yearly transmission rights.

Source: [Meeus]

Explicit auction – Limitation and Discussion

Coordination issues due to separation from energy trading.

To be able to bid for transmission rights, traders must predict hourly prices differences between zones – which is very difficult.

Discussion still going over what to do if a TSO must curtail long-term transmission rights (e.g. if they have a network problem).

How does the TSO compensate the market player that bought the transmission rights ?

Source: [Meeus]

Day-ahead and implicit auction

Implicit auction (or market coupling) implies that transmission rights are **included in the energy trading directly.**

In Europe, the day-ahead market has been integrated across countries to from the SDAC (Single Day-Ahead Coupling). The clearing is run in 10 minutes by an algorithm called EUPHEMIA (pan-European Hybrid Electricity Market Integration Algorithm). Transmission rights are integrated in the clearing.

EUPHEMIA is run jointly by all market operators (running the algorithm is called the Market Coupling Operator – MCO – function). Participating market operators are certified as NEMOs (Nominated Electricity Market Operators (NEMOs).' In 2020, 8 NEMOs, running the algo on a daily rotational basis.

Source: [Meeus]

Note on monopolies

Problem of market operators becoming monopolies

Example

In 2014, 6 million euros of fine to EPEX SPOT and NORDPOOL which had **agreed to not compete** on day-ahead and intra-day by separating the zones on which they were operating.

Source: [Meeus]

Types of transmission rights

Physical transmission rights

"A right entitling its holder to physically transfer a certain volume of electricity in a certain period of time between two bidding zones in a specific direction"

If the trader decides not to use the right, the UIOSI (use-it-or-sell-it) principle applies. It is compensated for the value of the right in a day-ahead auction, the price difference across the border becoming the implicit price for the transmission right.

Financial transmission rights Option/*Obligation*

"A right entitling its holder to receive financial remuneration (*or* obliging its holder to provide financial remuneration) based on the day-ahead allocation results between two bidding zones during a specified period of time in a specific direction."

Source: [Meeus], ACER Decision on HAR amendment: Annex 1

After day-ahead

Currently, intraday transmission rights are free.

First-come-first-served system: Given to first matched on the continuous trade platform until no more rights are available or border is closed (i.e. one hour before delivery).

Not market-based. Therefore, no transmission rights are reserved for the intraday stage; only the rights that have not been used in the day-ahead stage are allocated.

Currently mostly continuous trading (because small amounts sold) but ACER pushing for auctions which would allow to sell transmission rights like in the day-ahead.

Source: [Meeus]

Losses in transmission networks

Losses occur in electricity networks. Since one or more generators must produce this lost energy and since these generators expect to be paid for all the energy they produce, a mechanism must be devised to take losses and their cost into account in electricity networks.

Three types of losses: fixed losses, non-technical losses and variable losses.

Source: [Kirschen]

Fixed losses: Caused by

1. hysteresis and eddy current losses in the iron core of transformers and
2. corona effect in transmission lines.

These losses are proportional to the square of the voltage and independent of the power flows and, as first approximation, can be considered as being constant.

Non-technical losses: Energy which is stolen from the network.

Variable losses: Also called transported-related losses or copper losses. Proportional to the resistance R of the branch and to the square of the current in the branch.

Variable losses usually much higher than other losses. In western European countries, 1 to 3 % of the energy produced is lost in the transmission network and 4 to 9% in the distribution system.

Source: [Kirschen]

Handling losses under bilateral trading

Because losses are not a linear function of the flows in the transmission system, the losses caused by a transaction do not simply depend on the amount of power traded and the location of the two parties involved in the transaction. These losses also depend on all the other transactions taking place in the network.

Allocating the losses or their costs between all the market participants is thus a problem that does not have a rigorous solution.

A fair mechanism is one in which the participants that contribute more to losses pay a larger share than the others.

Source: [Kirschen]