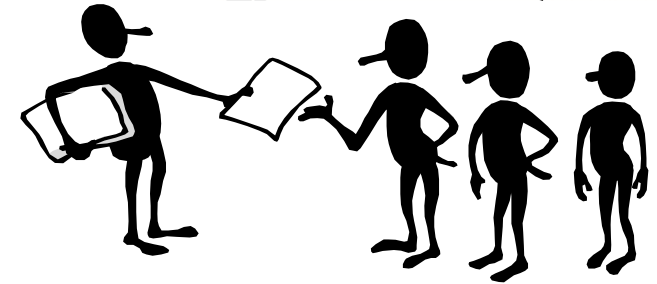


Introduction

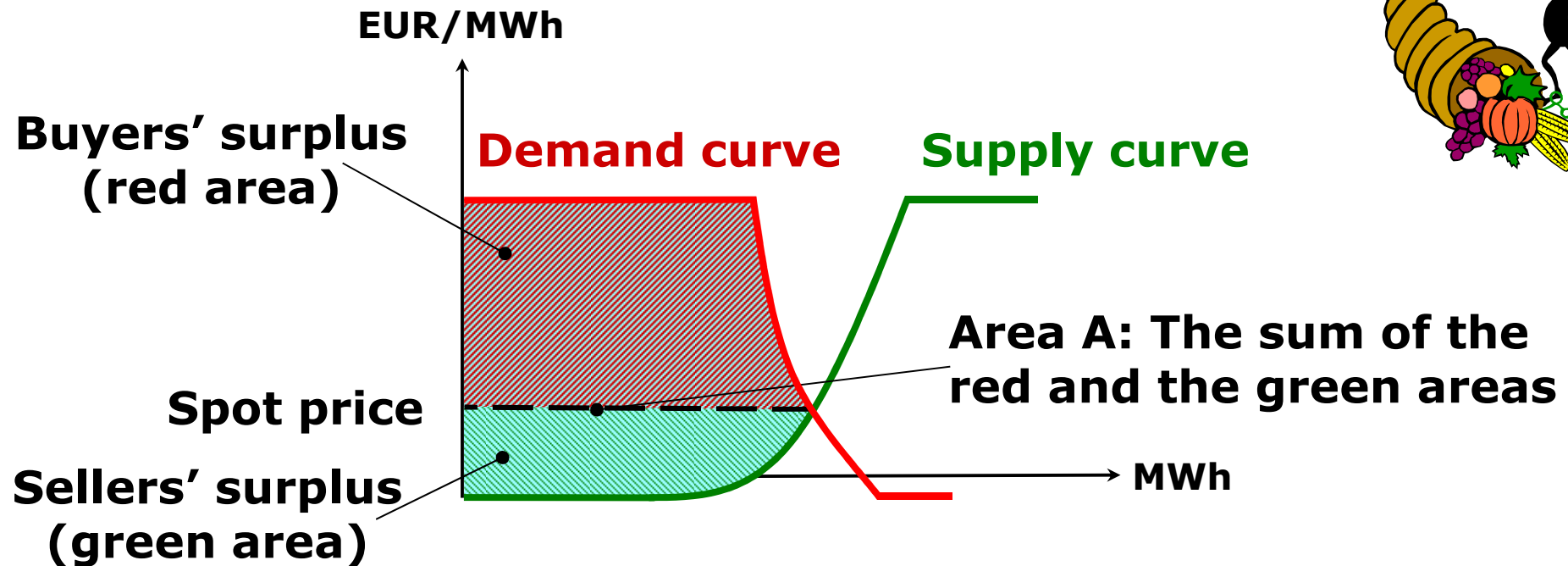


- **In the appendix, you'll find a list of the terms and acronyms used in this PowerPoint presentation.**
- **This PowerPoint presentation is animated**
 - **It's strongly recommended to run the animation when viewing the presentation.**
- **On most computers, you can start the animation by pressing F5.**
 - **Now the presentation moves one step forward, when you press Page Down. It moves one step backward, when you press Page Up.**

Welfare criterion

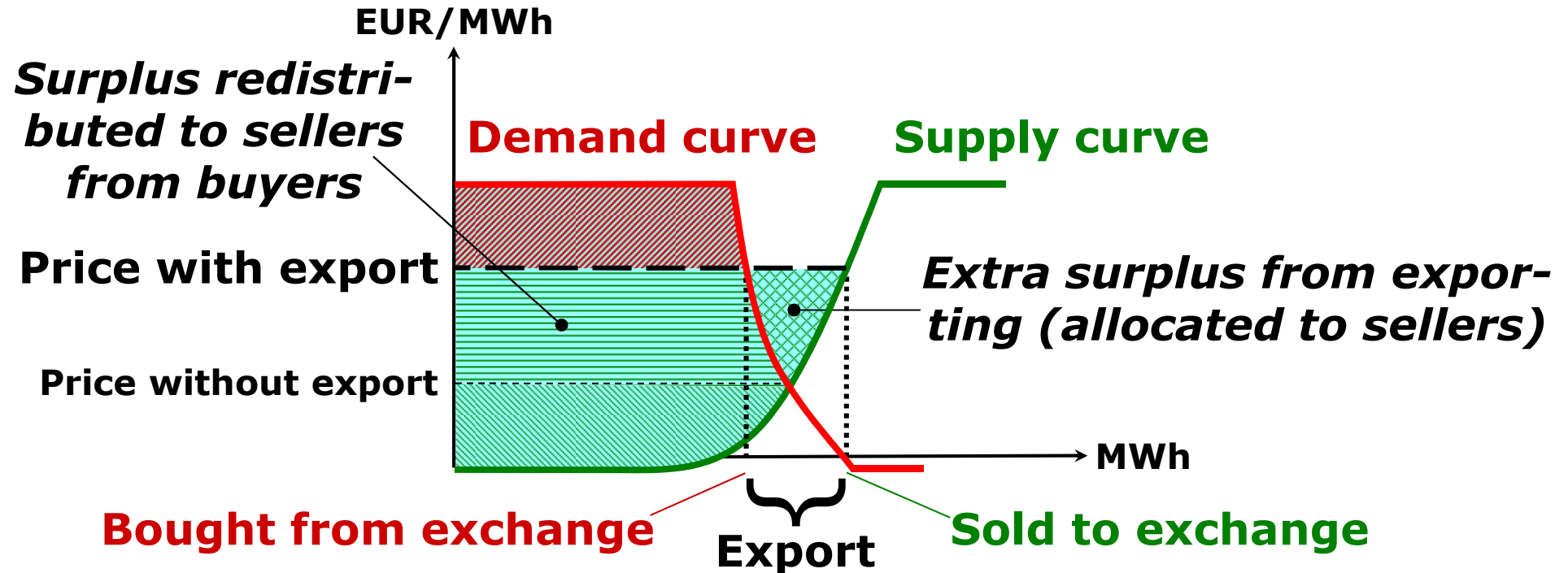
- **This PowerPoint presentation explains the so-called “welfare criterion”.**
- **Actually, the name is misleading, as the criterion does not aim at maximising society’s welfare.**
- **More modest, the criterion aims at maximising the economic value of the spot trading.**
- **Referring to the figure on the next slide:**
 - **On slide no. 14 it’s explained in detail why the area between the supply curve and the demand curve is the traders’ total surplus.**

Traders' surplus: no import/export



For one hour for one price zone: The buyers' and the sellers' total surplus from the spot trading is the area between the spot exchange's supply curve and the spot exchange's demand curve (the red/green area A).

Traders' surplus if the zone is exporting



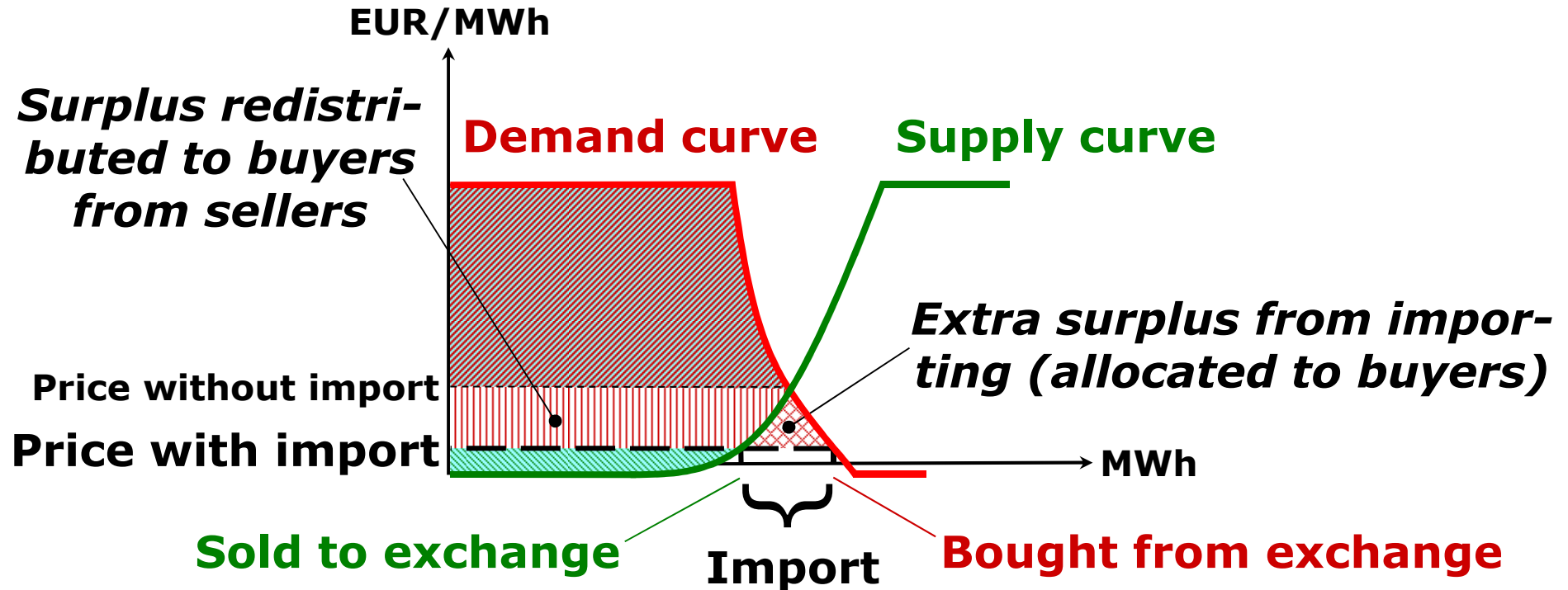
For one hour for an exporting price zone:

The difference between the local purchase from the exchange and the local sale to the exchange is the energy exported by the implicit auction system (this energy needs to be exported, as it is sold to the exchange; but not bought locally).

The export drives up the local price. Furthermore:

- A. The increase in spot price redistributes some of the local surplus to sellers from buyers.
- B. There is an increase in the total surplus. This is allocated to the sellers.

Traders' surplus if the zone is importing



For one hour for an importing price zone:

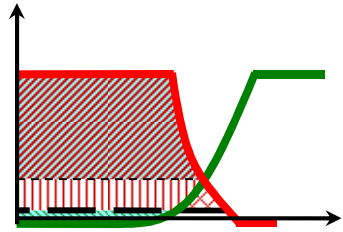
The difference between the local purchase from the exchange and the local sale to the exchange is the energy imported by the implicit auction system (this energy needs to be imported, as it is bought from the exchange; but not sold locally).

The import drives down the local price. Furthermore:

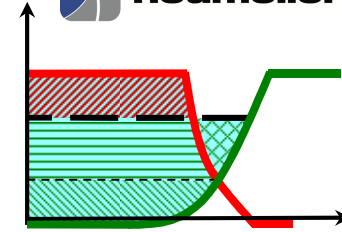
- A. The decrease in spot price redistributes some of the local surplus to buyers from sellers.
- B. There is an increase in the total surplus. This is allocated to the buyers.

Value created by the trading

- **For one hour of the next day: consider two neighbouring price zones with different prices P_{low} and P_{high} .**
- **If the implicit auction sends the energy E from the low-price zone to the high-price zone, the so-called congestion revenue (or congestion rent) is**
 - **$E * (P_{high} - P_{low})$.**
- **Normally, the congestion rent is given to the capacity owners.**
- **Actually, the total value created by the spot trading is the sum of the following two components:**
 - **The sum of all the red/green areas (the traders' surplus).**
 - **The congestion rent (the capacity owners' gain).**



Optimization - 1



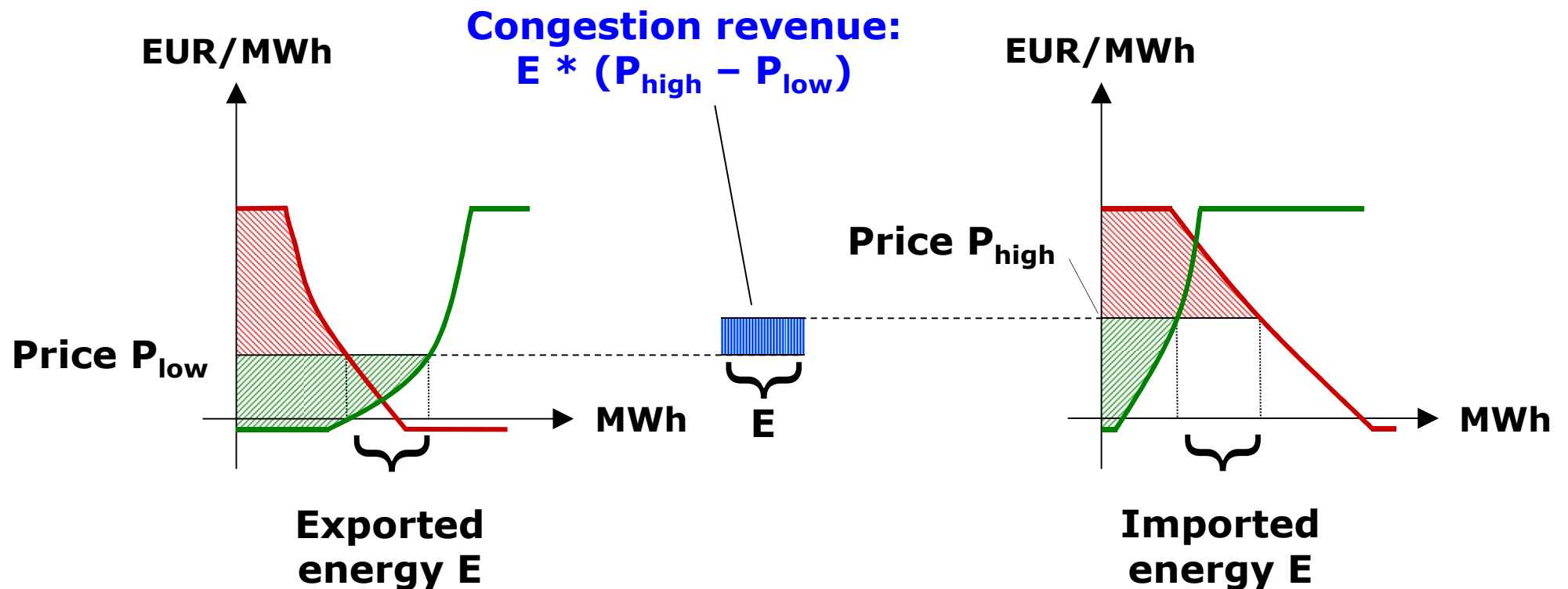
- When selecting the preferred solution, the spot trading software aims at maximising the value of the spot trading.
- With reference to the previous slides: it aims at maximising the sum of
 - The traders' surplus (all the red/green areas).
 - The congestion rent.
- The maximization runs over all links, all price zones and all 24 hours of the next day.
- Hence, the software aims at maximising the following sum:

$$\sum_{24 \text{ hours}} \left[\sum_{\substack{\text{All links} \\ \text{between} \\ \text{price zones}}} (\text{congestion rent}) + \sum_{\substack{\text{All} \\ \text{price} \\ \text{zones}}} (\text{traders' surplus}) \right]$$

Congestion revenue and traders' surplus for one hour. Only two price zones

Exporting zone

Importing zone

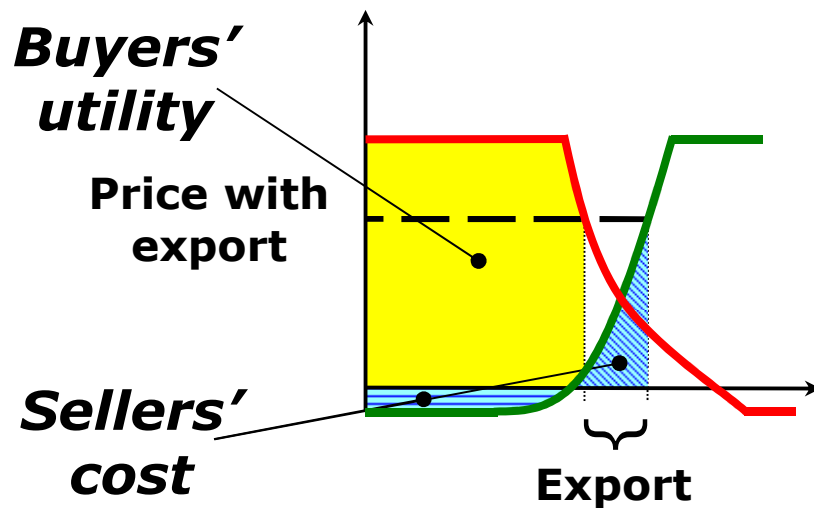


Green areas: sellers' surplus

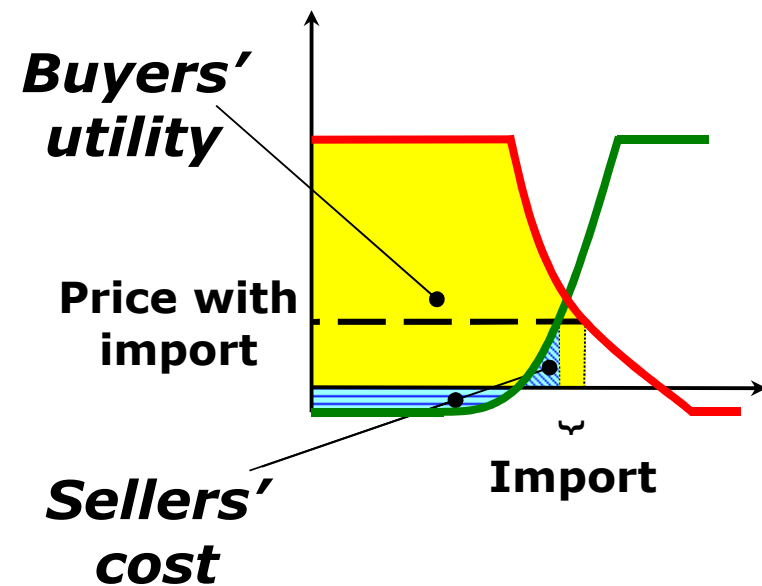
Red areas: buyers' surplus

Buyers' utility and sellers' cost

If the zone is exporting



If the zone is importing



The buyers' utility is the area under the exchange's demand curve (yellow area: from the second axis to the purchase volume)

The sellers' cost is the difference between the two blue areas: (blue area over the first axis) - (blue area under the first axis)

Optimization – 2

You can prove the following equality: *) **)

$$\sum_{24 \text{ hours}} \sum_{\text{All price zones}} [(\text{buyers' utility}) - (\text{sellers' cost})] =$$

$$\sum_{24 \text{ hours}} \left[\sum_{\text{All links between price zones}} (\text{congestion rent}) + \sum_{\text{All price zones}} (\text{traders' surplus}) \right]$$

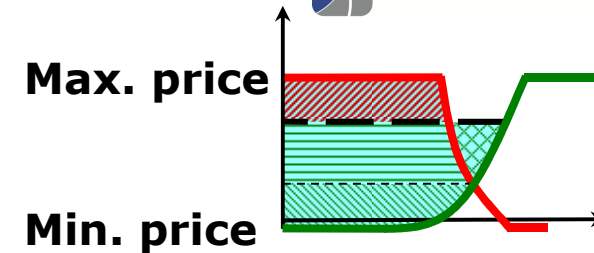
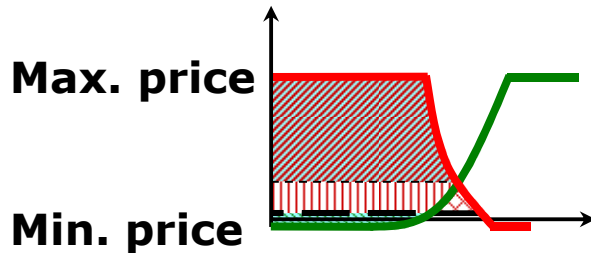
Therefore, the "welfare criterion" also aims at maximising the difference between the buyers' utility and the sellers' cost.

Which precisely means maximising the value of the spot trading.

****) For the mathematically interested, Houmoller Consulting has a paper proving the equality.***

******) Slide no. 9 illustrates the equation's left-hand side. Slide no. 8 illustrates the equation's right-hand side.***

Notes



- **The absolute value of the red/green areas should not be considered important**
 - **As it's heavily dependent upon the spot exchange's choice of maximum price and minimum price.**
- **However, when comparing different solutions, the relative size of the areas can be used to select the best solution.**
- **When this is used to select the preferred solution, the value of the spot trading is maximised**
 - **The bilateral trading and the exchange intra-day trading is invisible for the spot trading software. Therefore this cannot be included in the optimization.**

Appendix – terminology and acronyms – 1

As used in this presentation

- ***Double auction*** A calculation method whereby an exchange's price is set by calculating the intersection between the exchange's supply curve and the exchange's demand curve.
- ***Implicit auction*** The common term for market coupling and market splitting.
- ***Market coupling*** A day-ahead congestion management system, you can have on a border, where two electricity exchanges meet. The day-ahead plans for the cross-border energy flows are calculated using the two exchanges' bids and information on the day-ahead cross-border trading capacity.
- ***Market splitting*** A day-ahead congestion management system, you can have on a border, where you have the same electricity exchange on both sides of the border. The day-ahead plans for the cross-border energy flows are calculated using the exchange's bids and information on the day-ahead cross-border trading capacity.

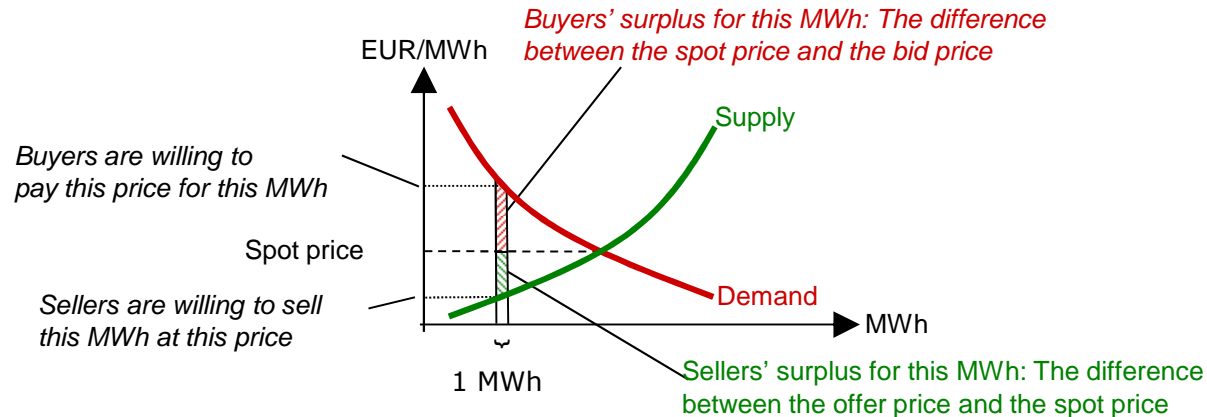
Appendix – terminology and acronyms – 2

As used in this presentation

- ***Price zone*** A geographical area, within which the players can trade electrical energy day-ahead without considering grid bottlenecks.
- ***Spot bid*** A purchase bid or a sales offer submitted to a spot exchange.
- ***Spot exchange*** In this document, a spot exchange is an exchange where
 - **Electrical energy is traded day-ahead.**
 - **The exchange's day-ahead prices are calculated by means of double auction.**
- ***Spot price*** A price calculated by a spot exchange. Either by a calculation performed by the spot exchange itself, or by a calculation performed by a body, to which the calculation has been outsourced.
- ***Spot trading software*** The software calculating the spot prices and the day-ahead plans for the cross-border energy flows.

Welfare criterion explained in detail

No exchange of energy with other price zones



Please refer to the figure above. Here, we consider the buyers' and the sellers' surplus for one MWh.

The buyers are willing to pay a rather high price for this MWh. However, also for this MWh, the buyers will pay the spot price.

Hence the buyers' surplus for this MWh is the red area:

$$[(\text{The buyers' bid price for this MWh}) - (\text{The spot price})] * 1 \text{ MWh}$$

For the MWh in question, the sellers are willing to sell at a rather low price. However, also for this MWh, the sellers will get the spot price.

Hence the sellers' surplus for this MWh is the green area:

$$[(\text{The spot price}) - (\text{The sellers' offer price for this MWh})] * 1 \text{ MWh}$$

Now please refer to the picture on slide no. 3 in this PowerPoint presentation: by considering all the energy traded, we conclude from the argument above that the total surplus for both the sellers and the buyers is the area between the supply curve and the demand curve.

Thank you for your attention!

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