

Frequency Keeping Selection (FK)

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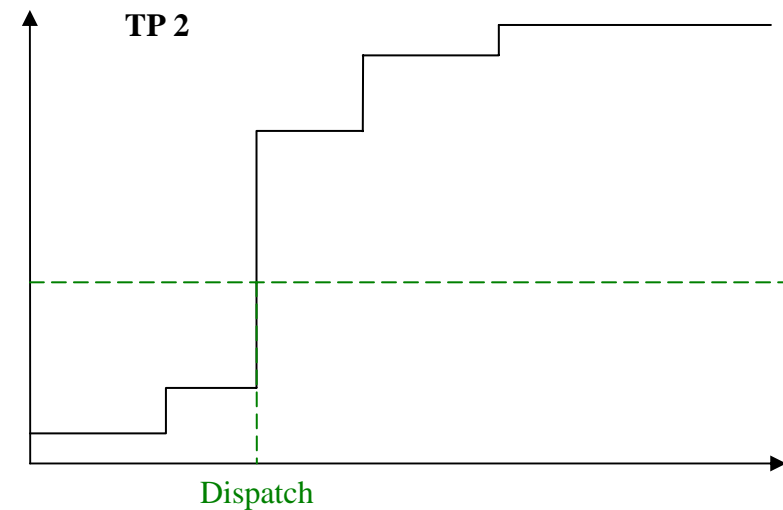
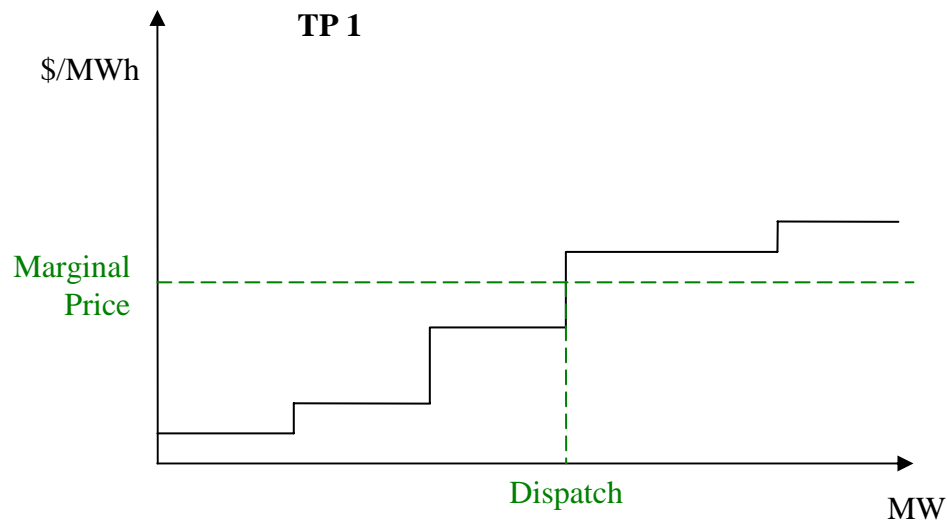
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Energy Offers

- Generators submit energy offers for each trading period
- Energy can be offered in up to 5 tranches
- Generators structure their offers depending on where they want to generate, given costs, marginal prices and their portfolio balance

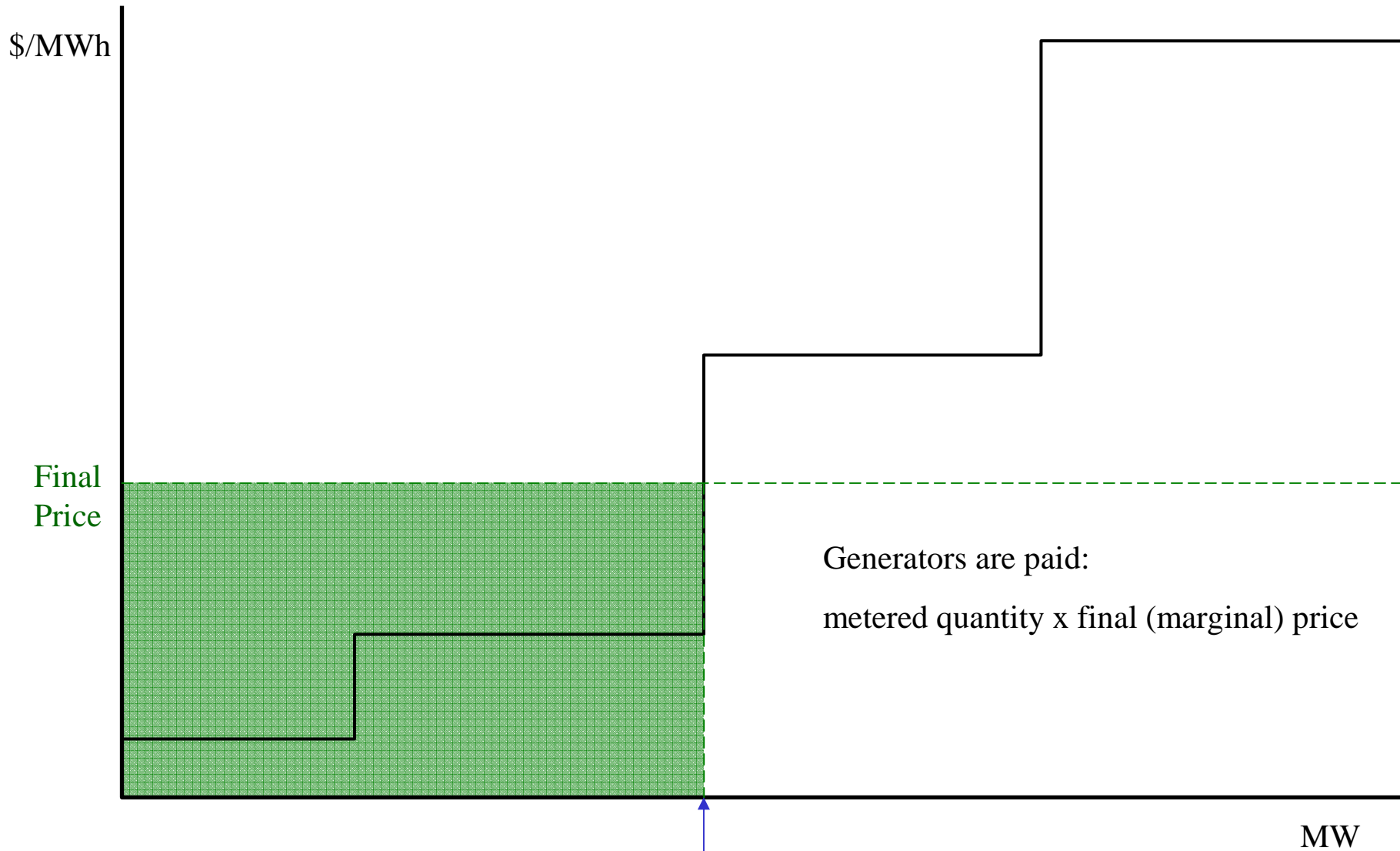


Dispatch

- The System Operator issues dispatch instructions so that generation (supply) equals demand at minimum cost
- Generators must comply with dispatch instructions
- Generators are paid:
metered quantity x final (marginal) price



Payments to Generators



Metered Quantity
= Dispatch

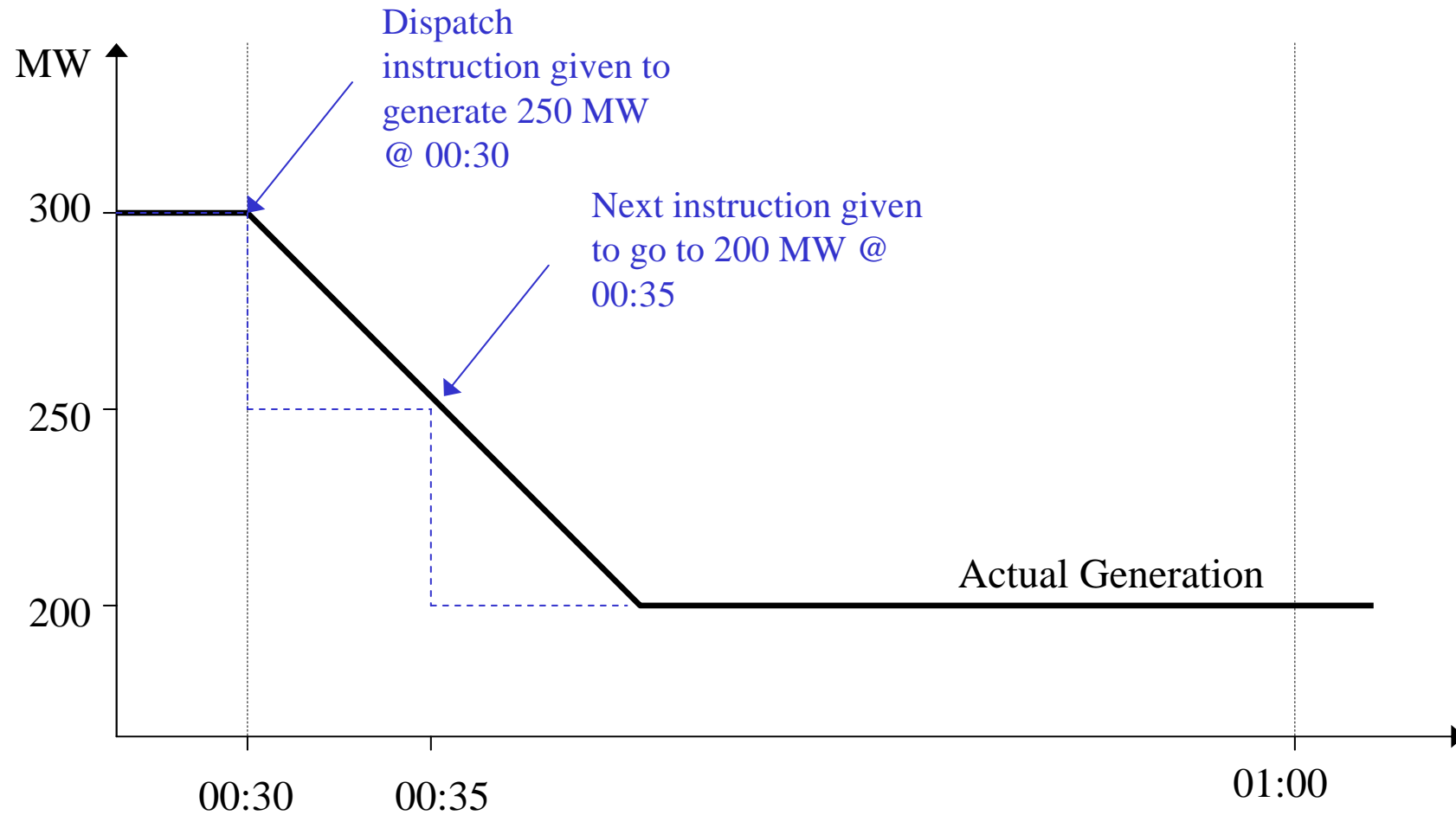


Constrained On and Off

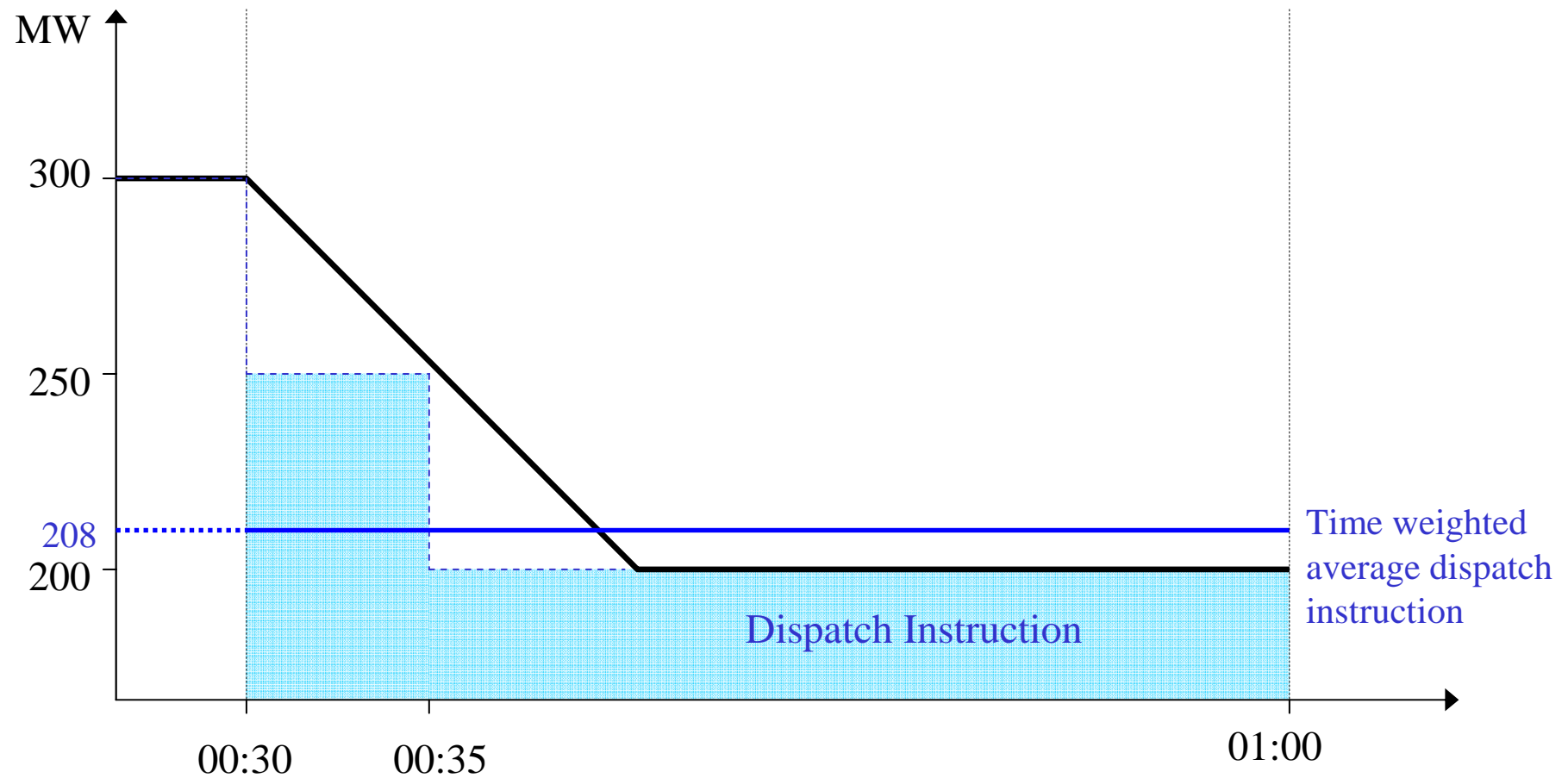
- Constrained on amounts are compensation payments made to a generator when that generator has metered energy above the level cleared in the final pricing process
- Constrained off amounts are compensation payments made to FK providers when that FK has metered energy below the level cleared in final pricing
- Constrained on and off quantities are required to compensate the generator for operating away from their set point at the cost of doing so
- Examples of when constrained on or off situations may occur are:
 - When a generator is ramp rate constrained
 - When a generator has been selected to frequency keep



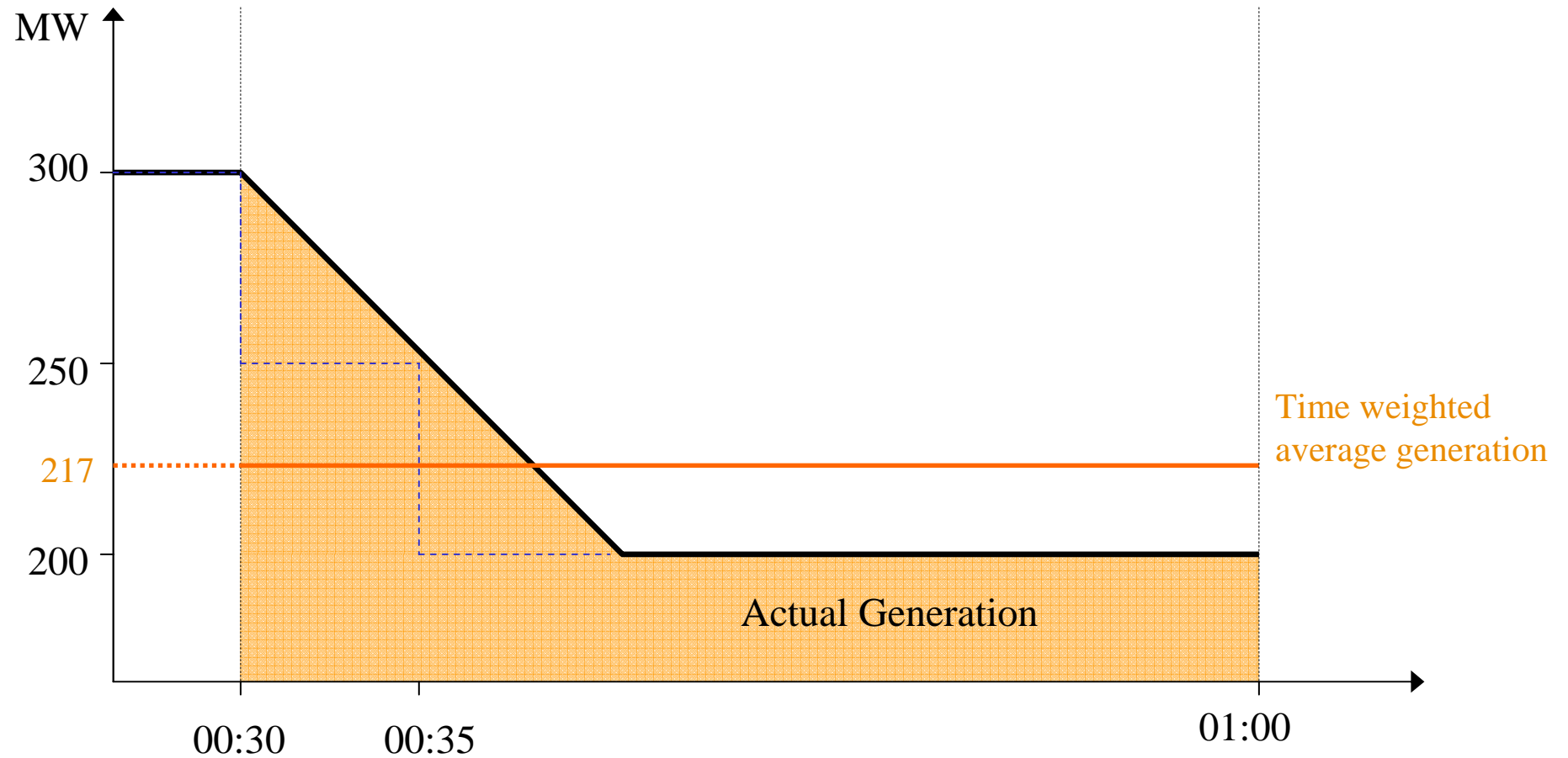
Ramp Rate Constrained On Example (1)



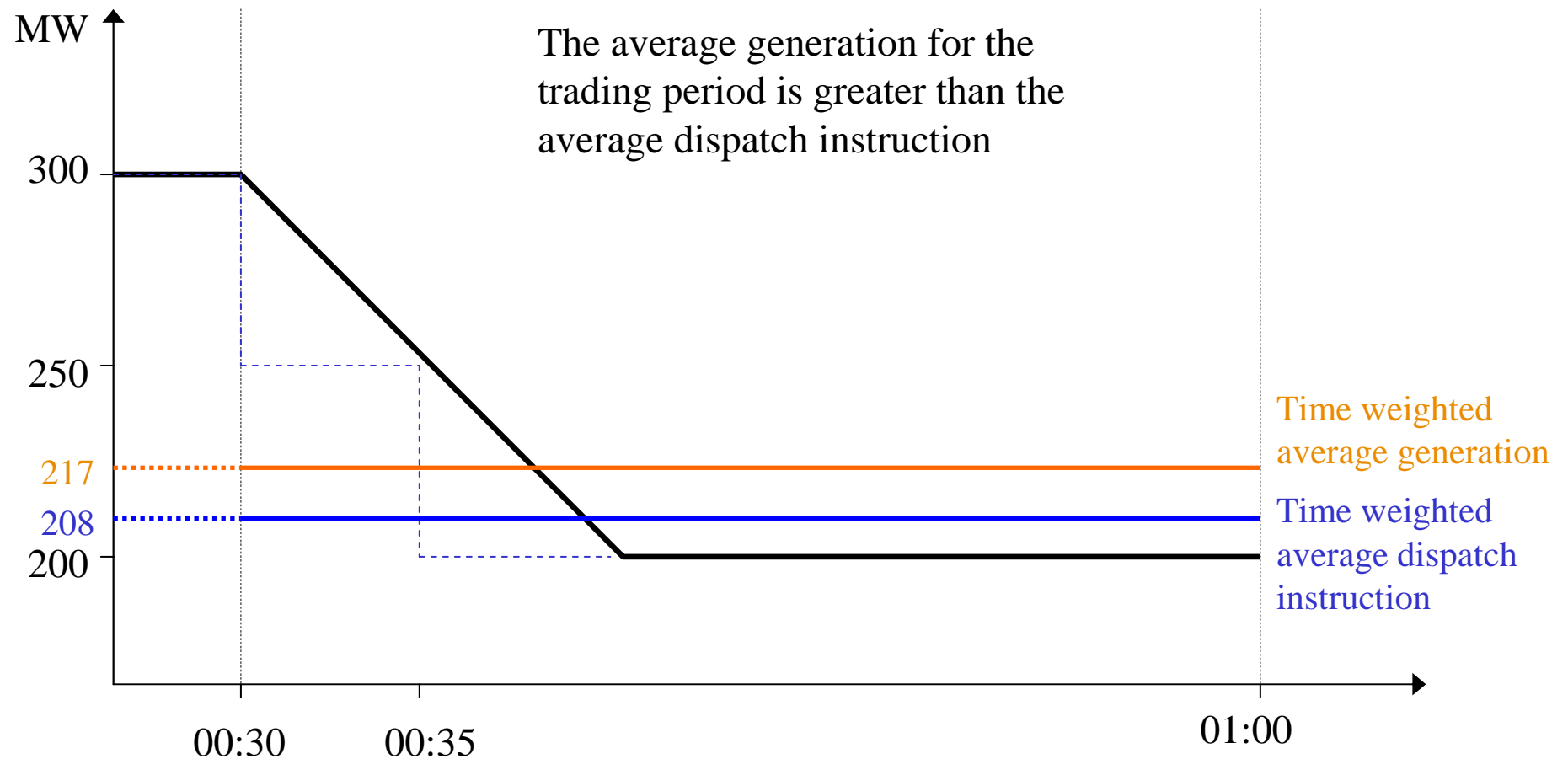
Ramp Rate Constrained On Example (2)



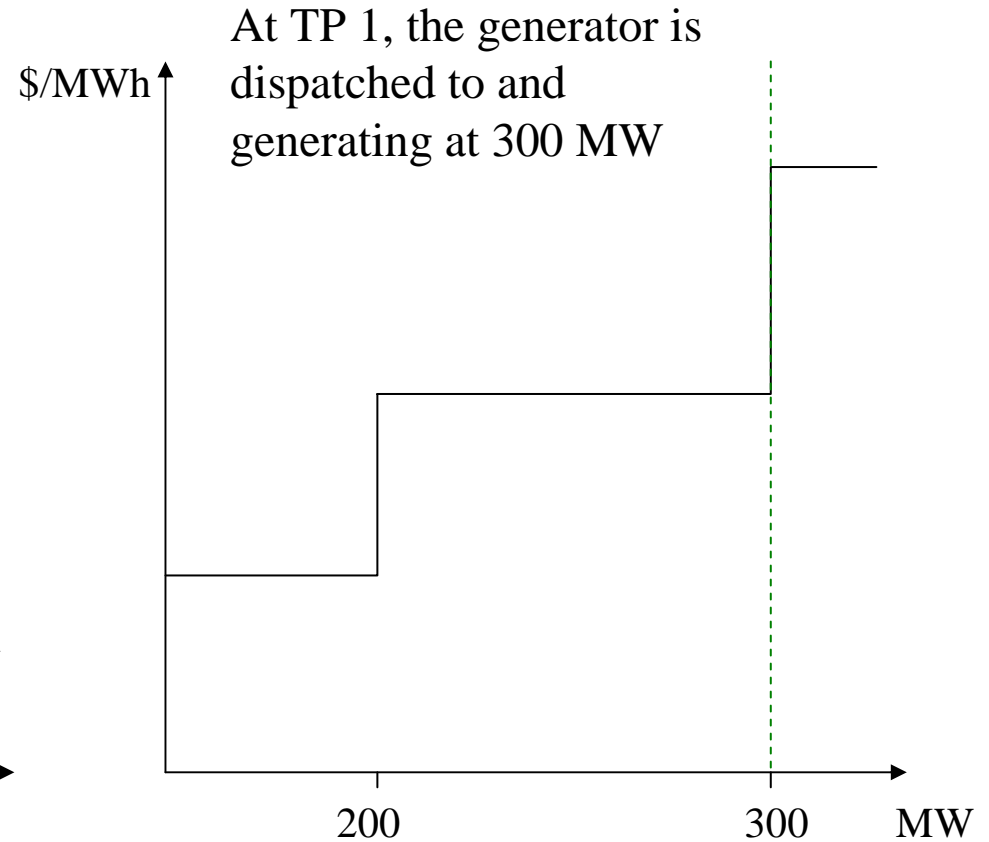
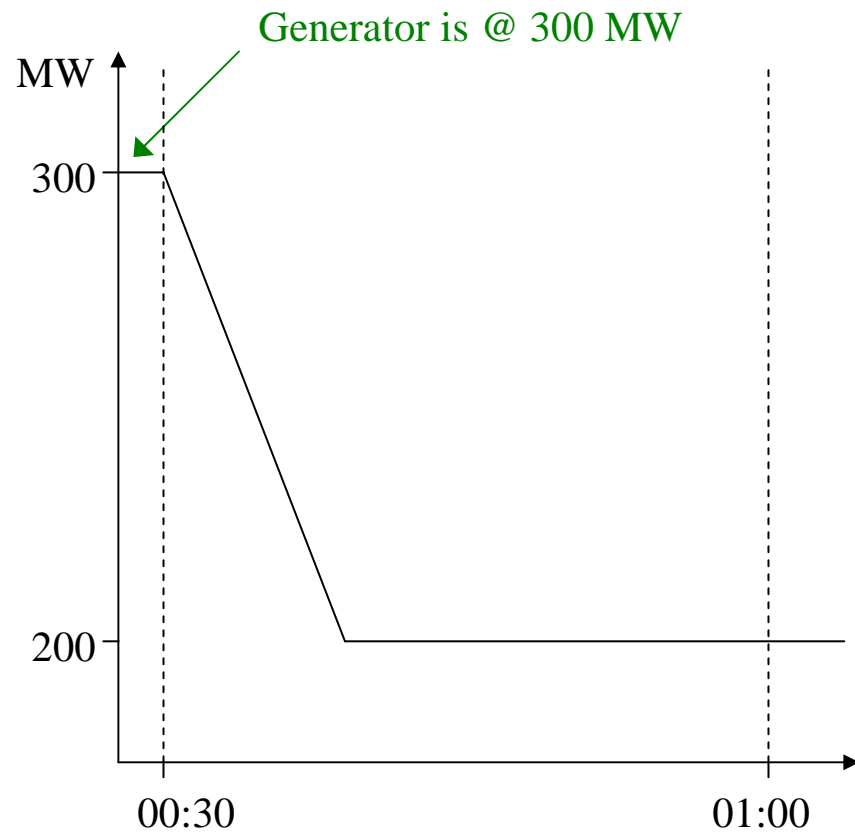
Ramp Rate Constrained On Example (3)



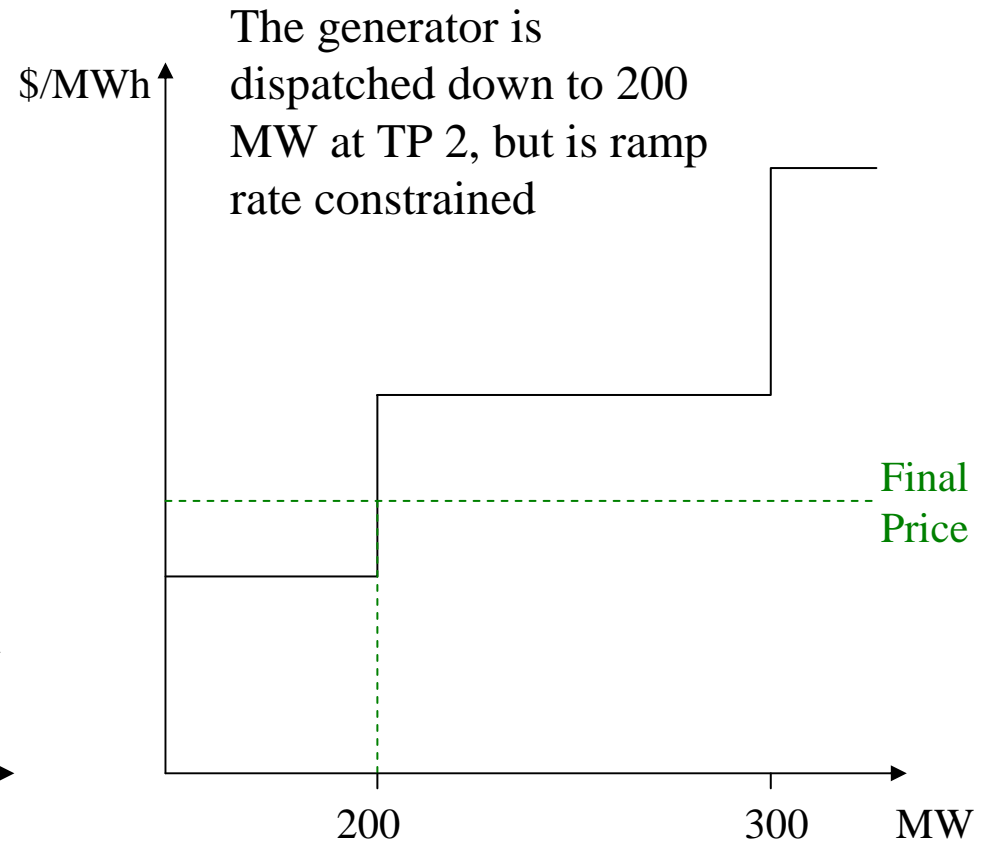
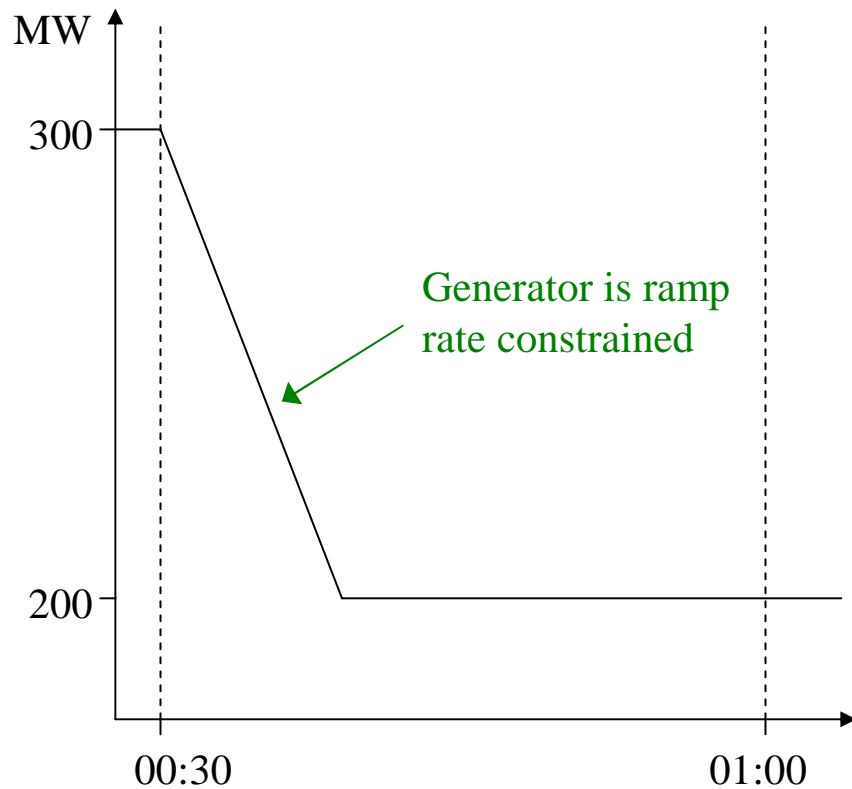
Ramp Rate Constrained On Example (4)



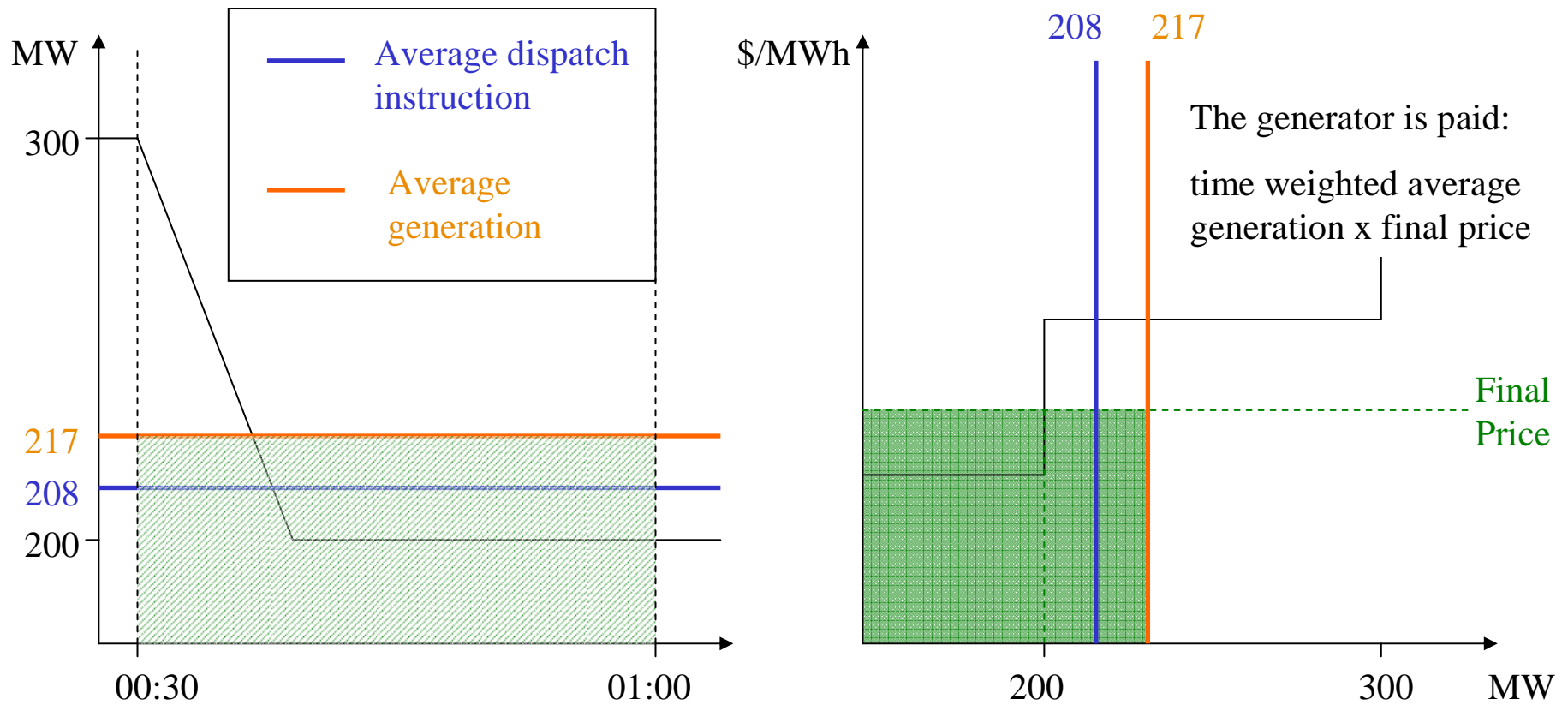
Ramp Rate Constrained On Example (5)



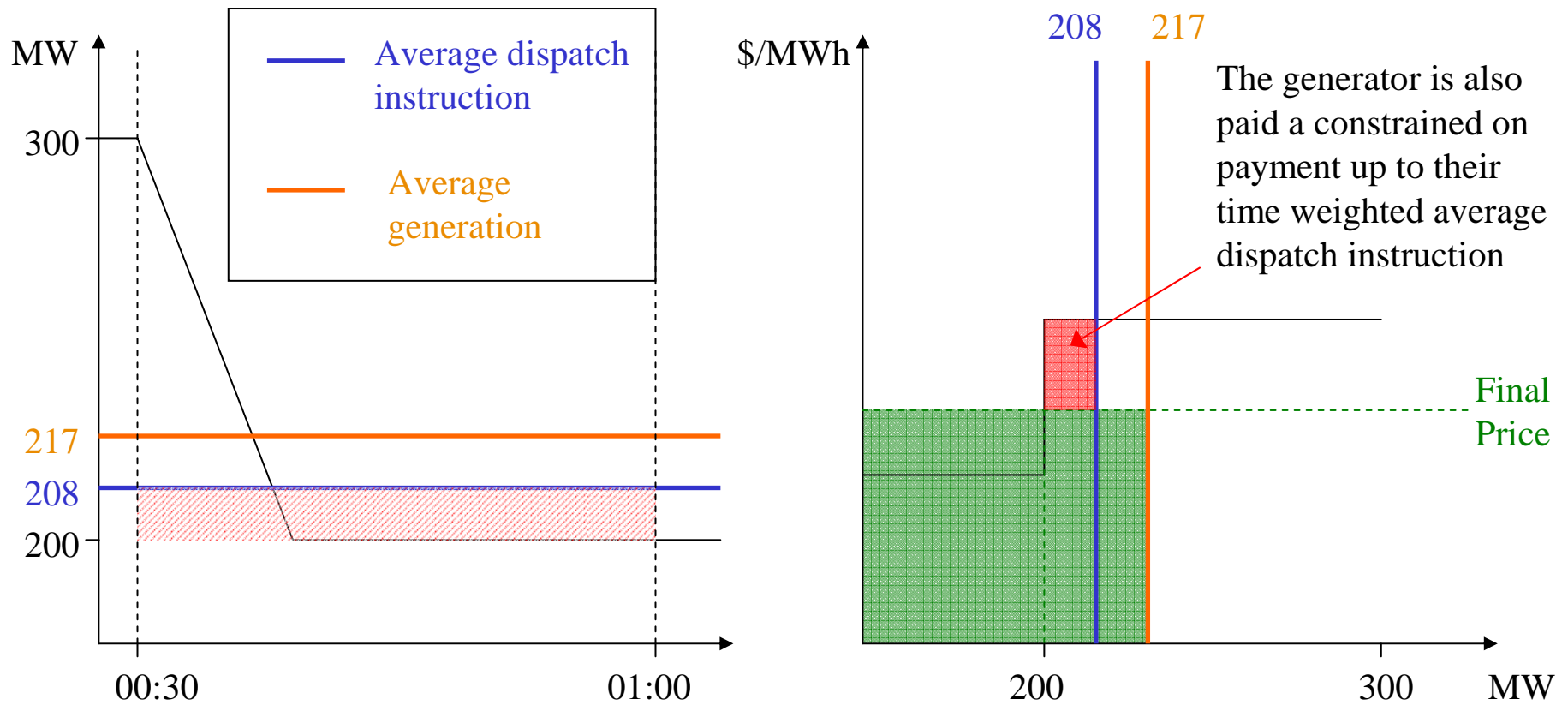
Ramp Rate Constrained On Example (6)



Ramp Rate Constrained On Example (7)



Ramp Rate Constrained On Example (8)



Role of the Frequency Keeper (FK)

- When supply is balanced with demand the system frequency is at 50 Hz
- It is important that frequency remains close to 50 Hz for operational, security and quality of supply reasons
- The frequency keeper (FK) has the role of maintaining the system frequency between a normal operating range of 49.8 to 50.2 Hz
- Unlike other generators, the FK may deviate from its dispatch set point in order to maintain system frequency



Frequency Keeping Offers

- FK providers submit FK offers for each trading period
- FK offers include parameters set by the FK provider. These parameters may vary between offers for each half hour :

Control Min	The lower MW limit the FK provider is capable of operating to in order to maintain frequency within the normal band
Control Max	The upper MW limit the FK provider is capable of operating to in order to maintain frequency within the normal band
Band Power	The +/- MW bandwidth that the FK is willing to deviate from its dispatch set point in order to maintain frequency within the normal band
Band Price	Offer price. Must be a positive value



Frequency Keeper Selection (1)

- Frequency keeper selection is based on the band power and price only
- FK selection does not take constrained on or off costs into consideration
- Selection is made based on the cheapest combination of band quantities and prices that make up frequency band required. This requirement is generally set at 50 MW
 - i.e can have three stations/units for same trader providing frequency keeping service that together make up the frequency band



Frequency Keeper Selection (2)

- Example calculation

Given that the FK requirement is a band of 50 MW, suppose trader X submits the following FK offers:

Unit	Band (MW)	Price (\$)
1	15	100
2	15	150
3	20	180
4	30	200
5	50	400



Frequency Keeper Selection (3)

- Example calculation

Given that the FK requirement is a band of 50 MW, suppose trader X submits the following FK offers:

Unit	Band (MW)	Price (\$)	
1	15	100	\$430
2	15	150	
3	20	180	
4	30	200	
5	50	400	\$400

Unit 5 makes up the required 50 MW band at a total price of \$400

A combination of units 1, 2 and 3 also make up the 50 MW band but at a total price of \$430



Frequency Keeper Selection (4)

- Example calculation

Given that the FK requirement is a band of 50 MW, suppose trader X submits the following FK offers:

Unit	Band (MW)	Price (\$)
1	15	100
2	15	150
3	20	180
4	30	200
5	50	400

Annotations: Arrows point from the text "\$300" to the right side of the rows for Unit 1 and Unit 4, indicating their combined total price.

A combination of units 1 and 4 has a total offer price of \$300, but this combination would not be selected as it does not make up the 50 MW band requirement (only totals 45 MW)



Frequency Keeper Selection (5)

- Example calculation

Given that the FK requirement is a band of 50 MW, suppose trader X submits the following FK offers:

Unit	Band (MW)	Price (\$)	
1	15	100	
2	15	150	
3	20	180	\$380
4	30	200	
5	50	400	

Units 3 and 4 will be selected to FK as this is the cheapest combination that meets or exceeds the required frequency band.



Frequency Keeper Selection (6)

- The System Operator makes the final FK selection for each island two hours before the beginning of each trading period
- Once the FK is selected, the System Operator applies market node constraints to ensure that the FK is dispatched between the offered control min and control max values. For example:

$$\text{ENOF} \geq \text{Control Min} + \text{bandwidth}$$

$$\text{ENOF} \leq \text{Control Max} - \text{bandwidth}$$

$$\text{ENOF} + \text{PLRO}(60\text{s}) + \text{TWRO}(60\text{s}) \leq \text{Control Max} - \text{bandwidth}$$

$$\text{ENOF} + \text{PLRO}(6\text{s}) + \text{TWRO}(6\text{s}) \leq \text{Control Max} - \text{bandwidth}$$

These values determine the dispatch set point for the FK



where

ENOF means energy offer

PLRO means partly loaded spinning reserve offer

TWRO means tail water depressed reserve offer

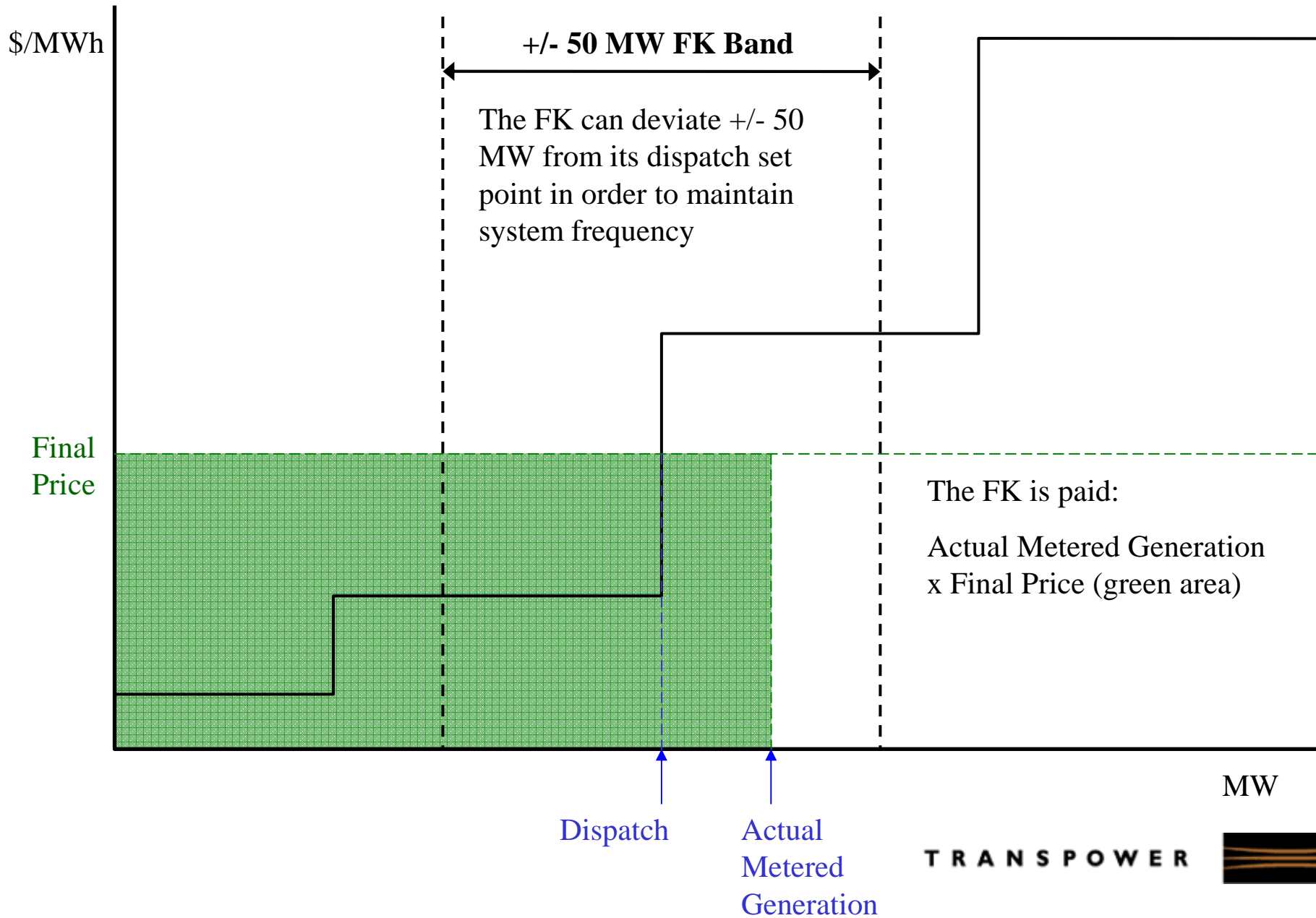


Examples (1)

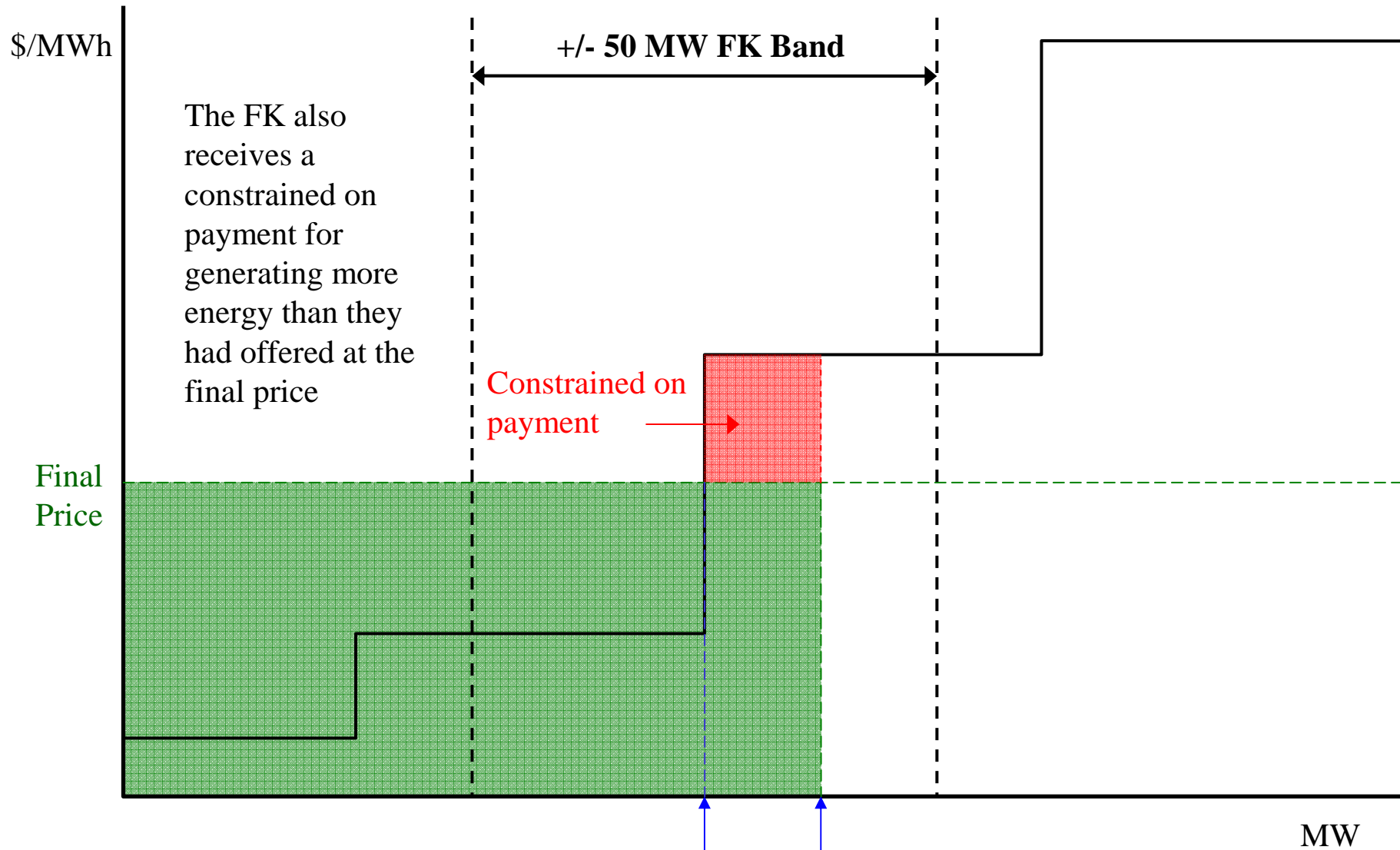
- The following examples show a single FK dispatched to meet a 50 MW frequency keeping band requirement.
- The following are simplified examples to illustrate:
 1. Constrained on for FK
 2. Constrained off for FK



Constrained On (1)



Constrained On (2)



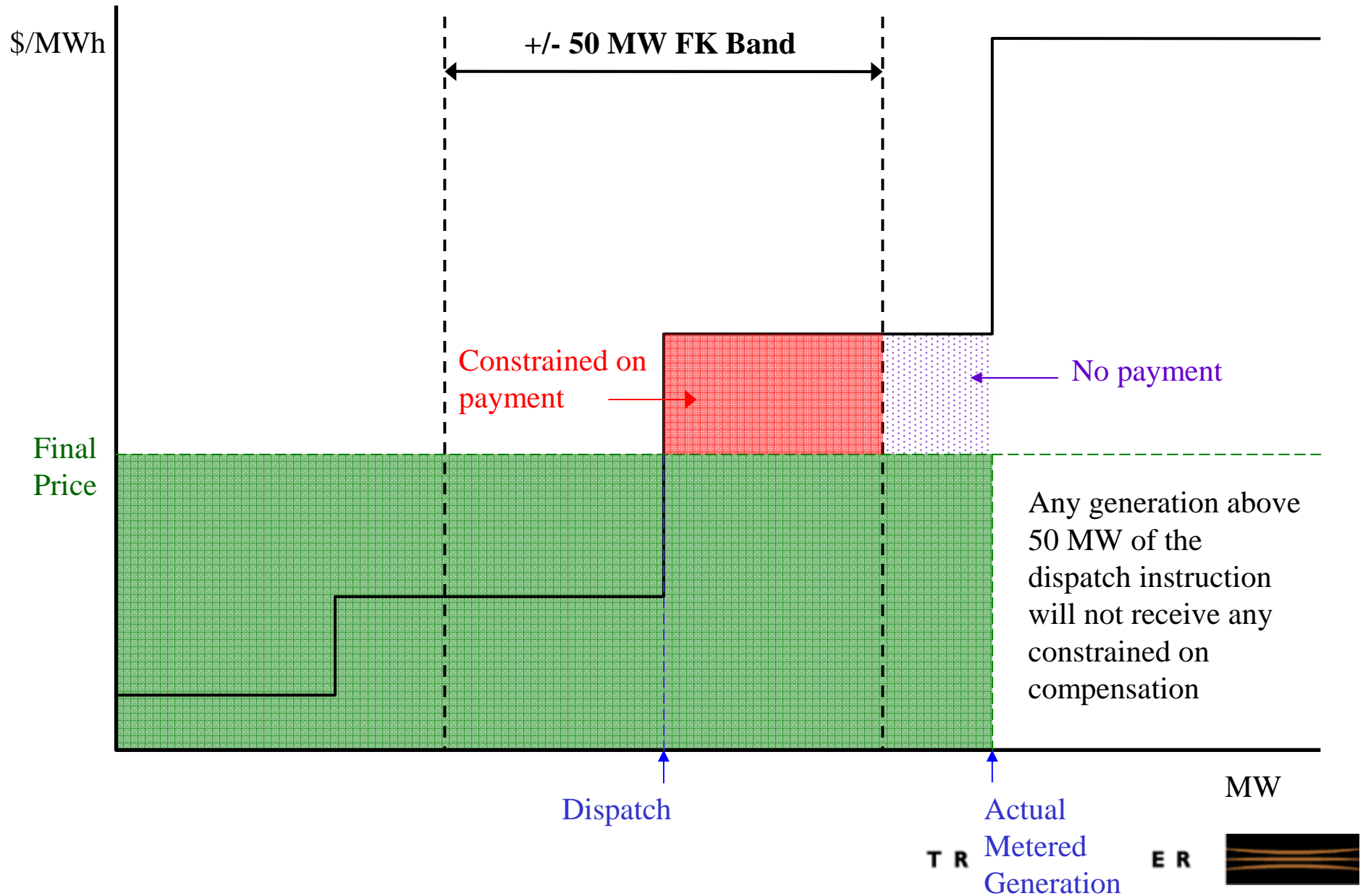
Dispatch

Actual Metered Generation

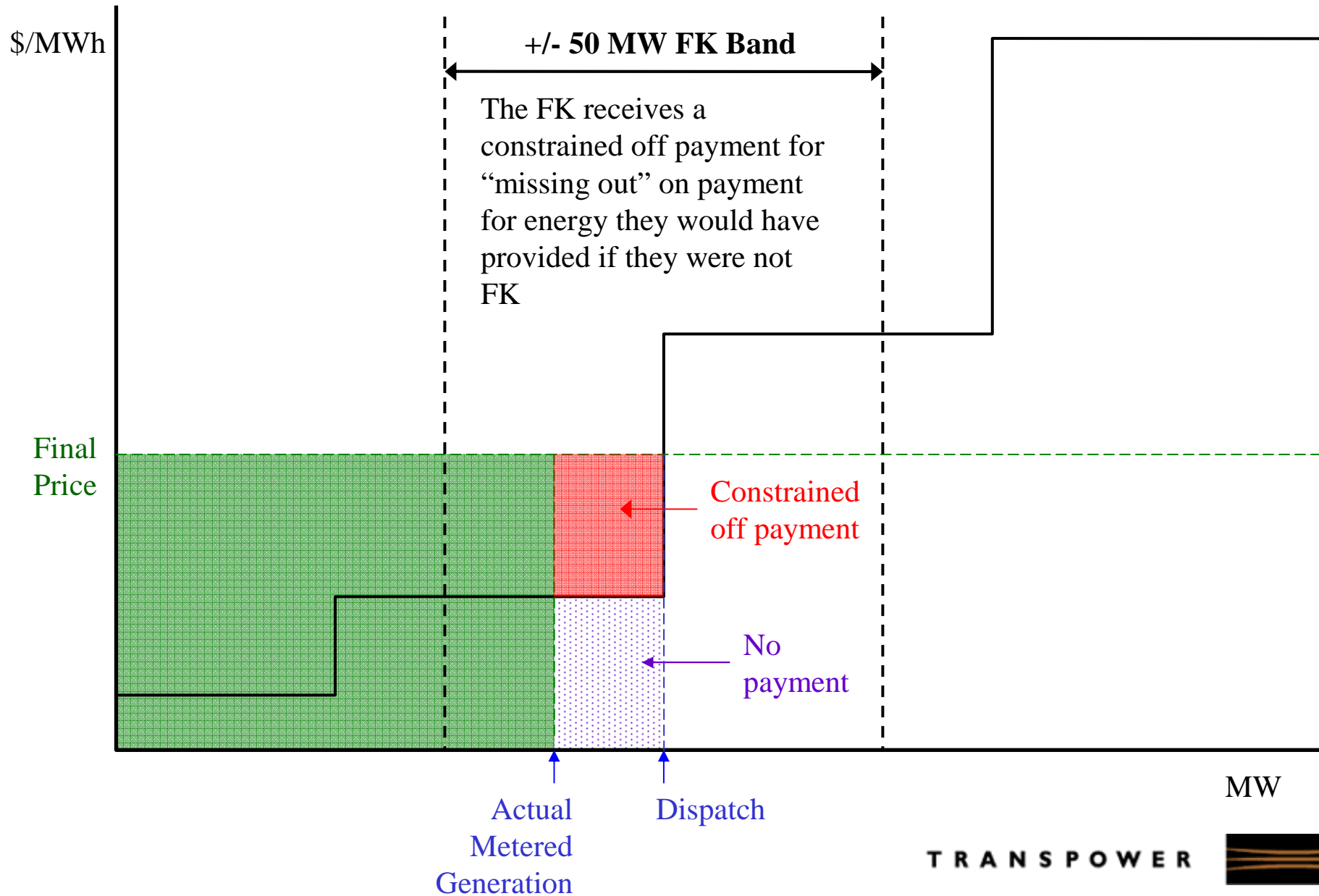
TRANSPower



Constrained On – outside FK band



Constrained Off

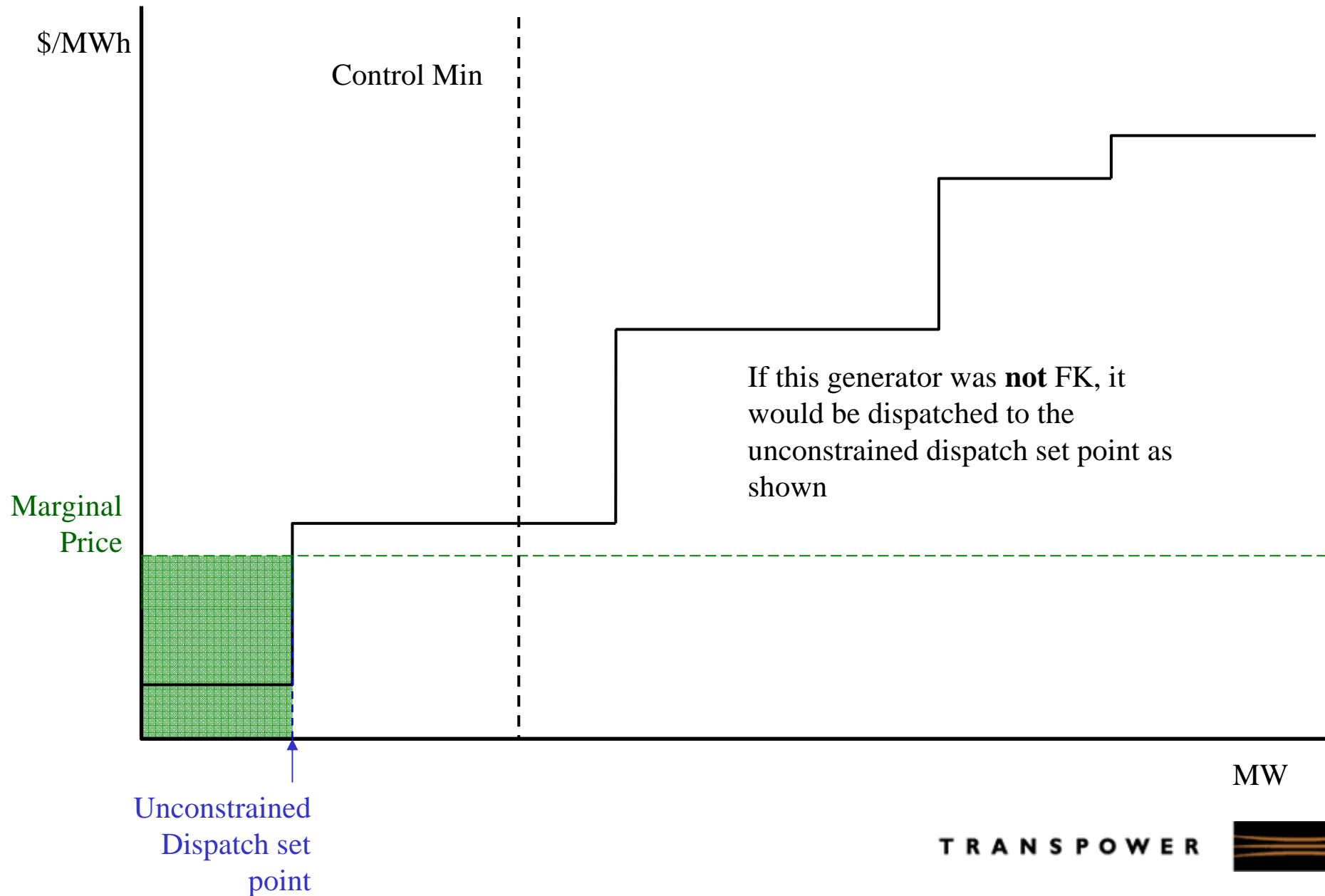


Examples (2)

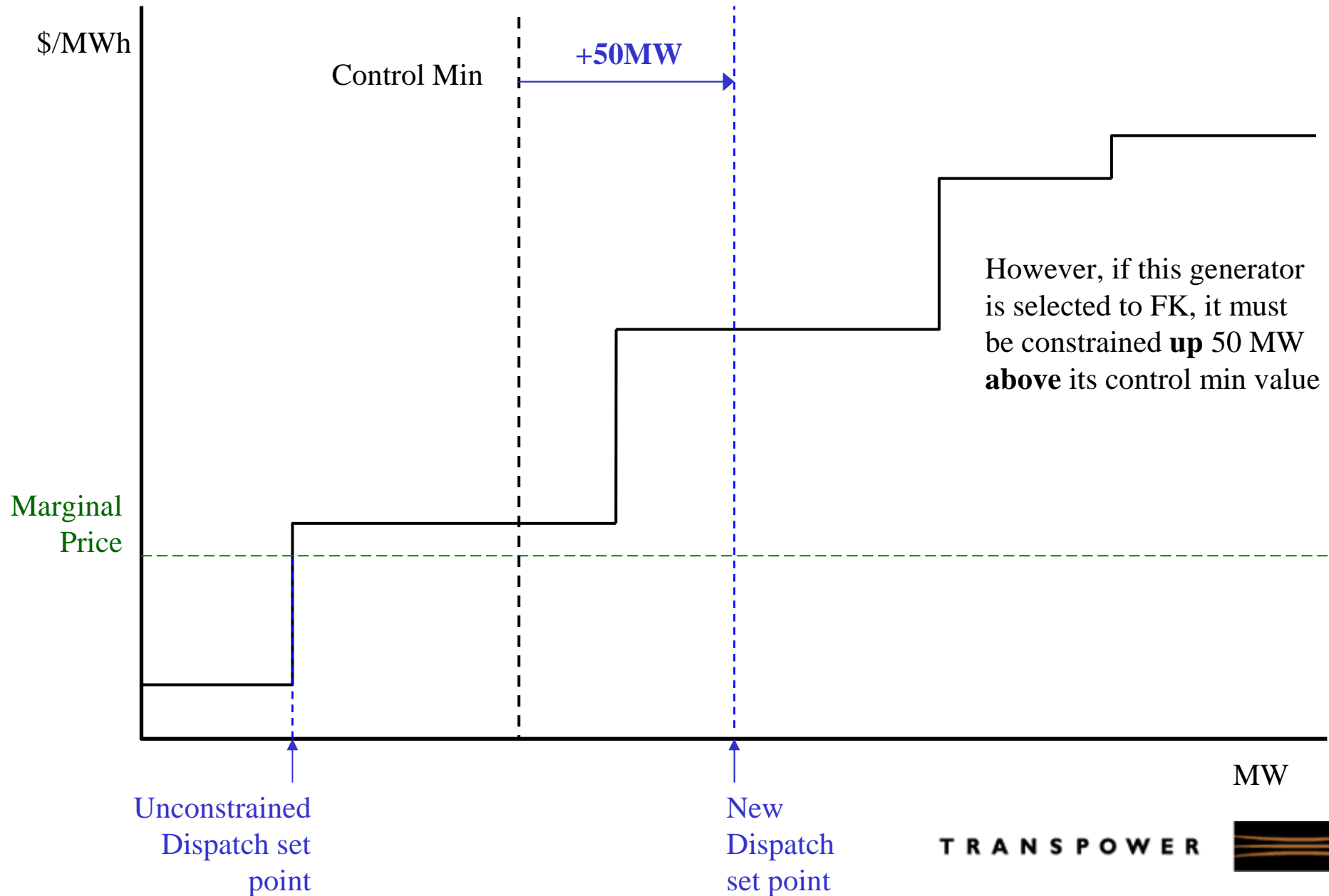
- The previous examples showed the same frequency keeper for 3 different trading periods
- Now let's assume that there is a different FK for each of the following examples. These examples illustrate:
 1. Control min and constrained on
 2. Control max and constrained off
 3. Effect on the marginal price



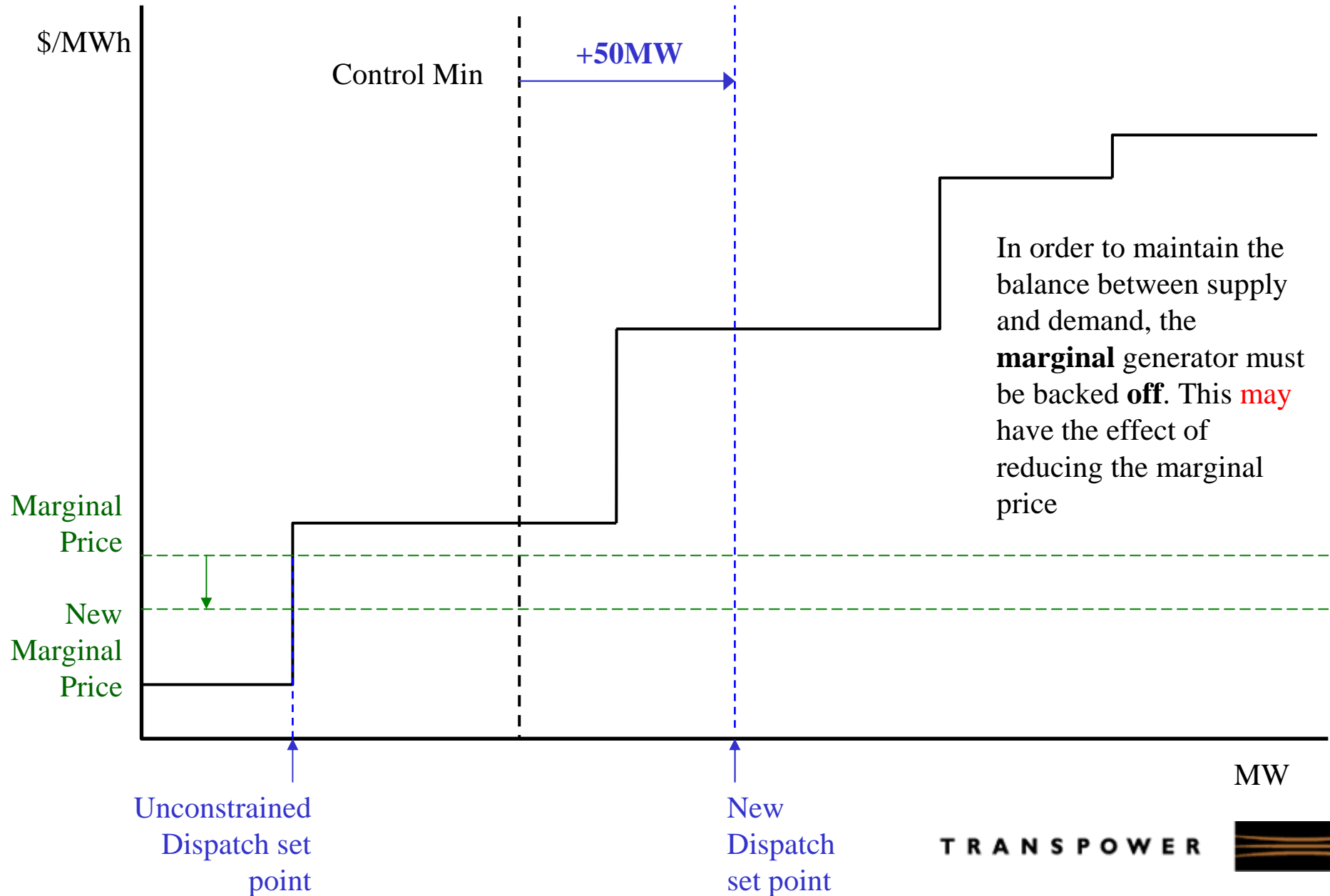
Control Min & Constrained On (1)



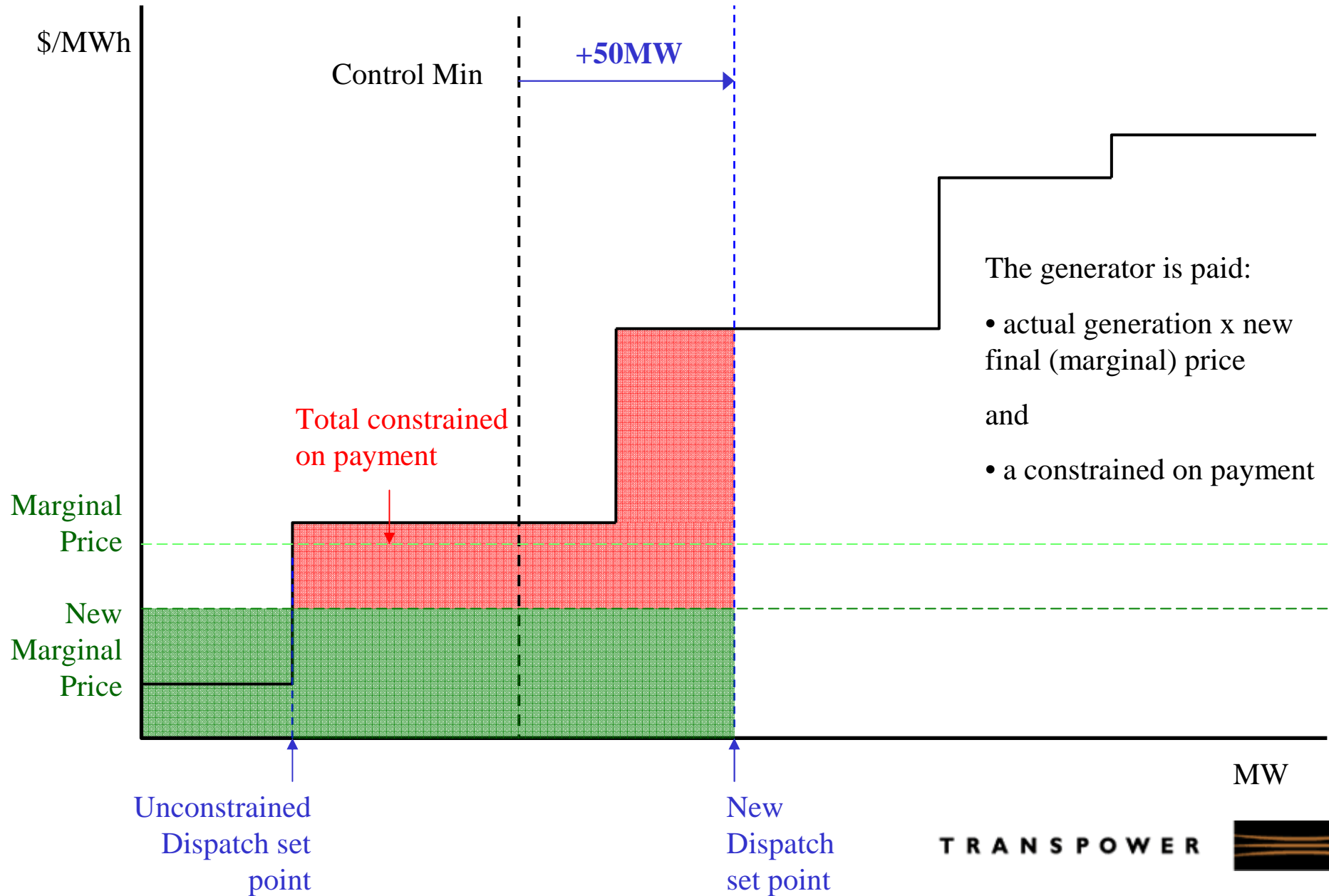
Control Min & Constrained On (2)



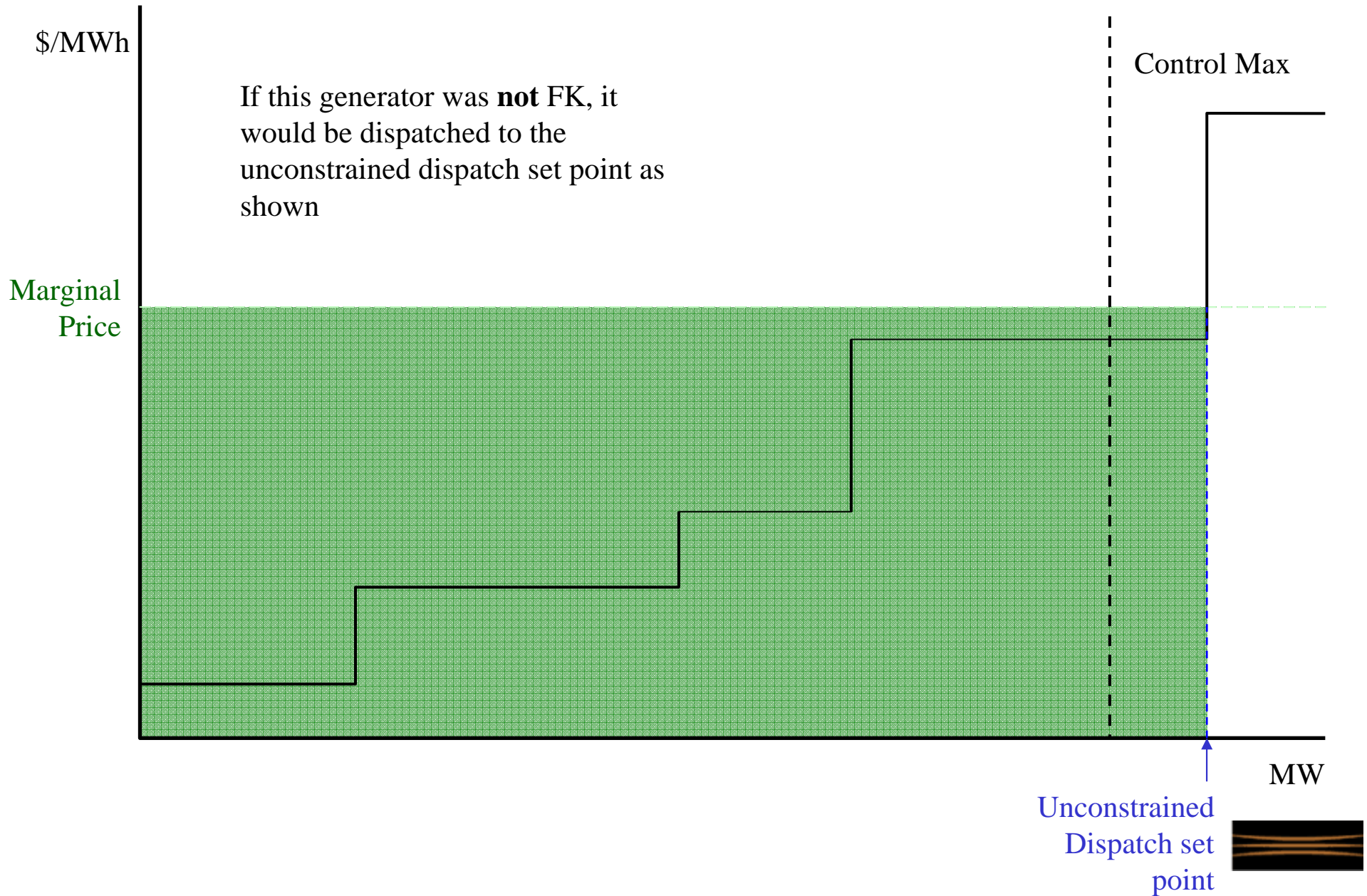
Control Min & Constrained On (3)



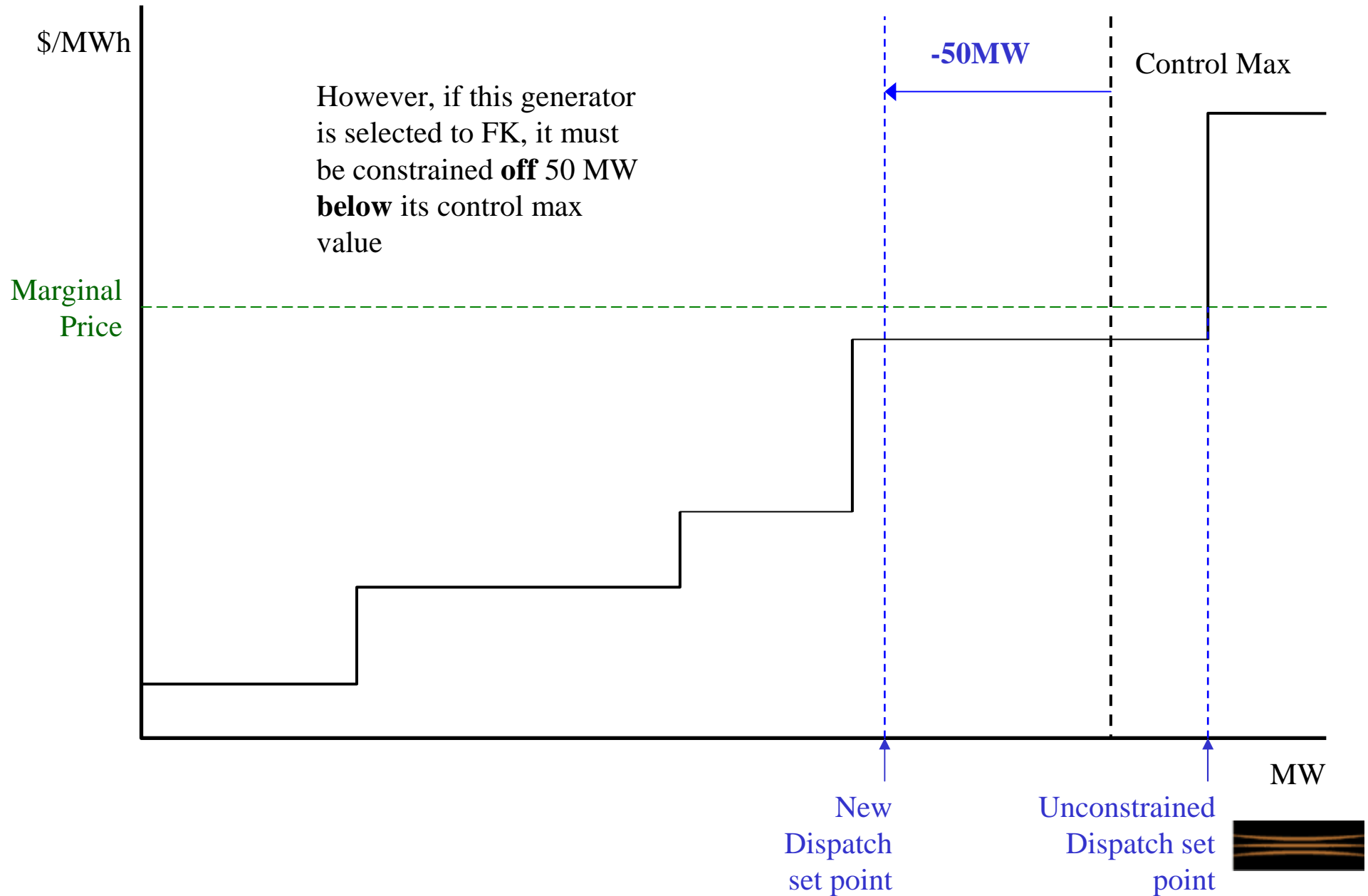
Control Min & Constrained On (4)



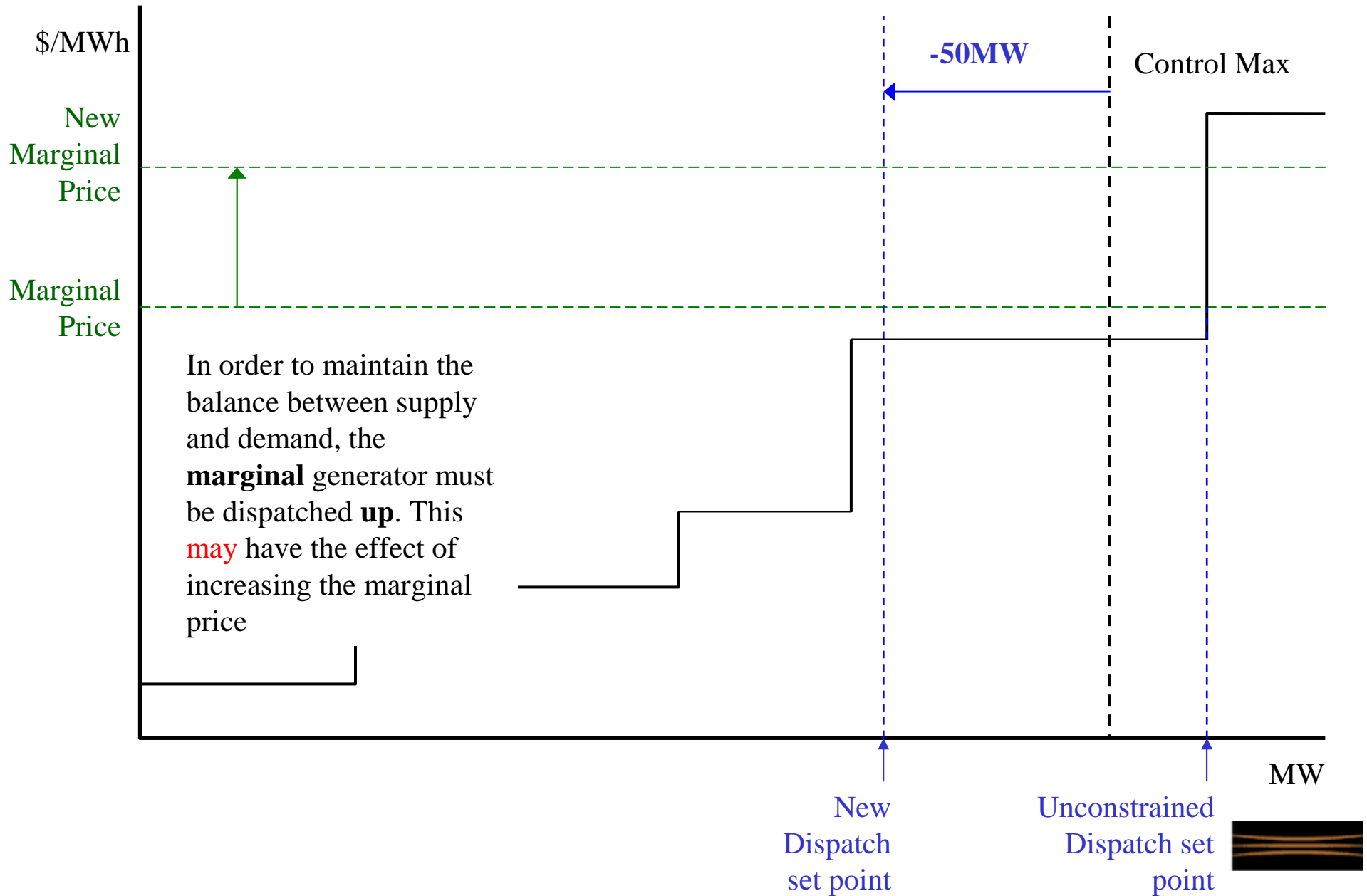
Control Max & Constrained Off (1)



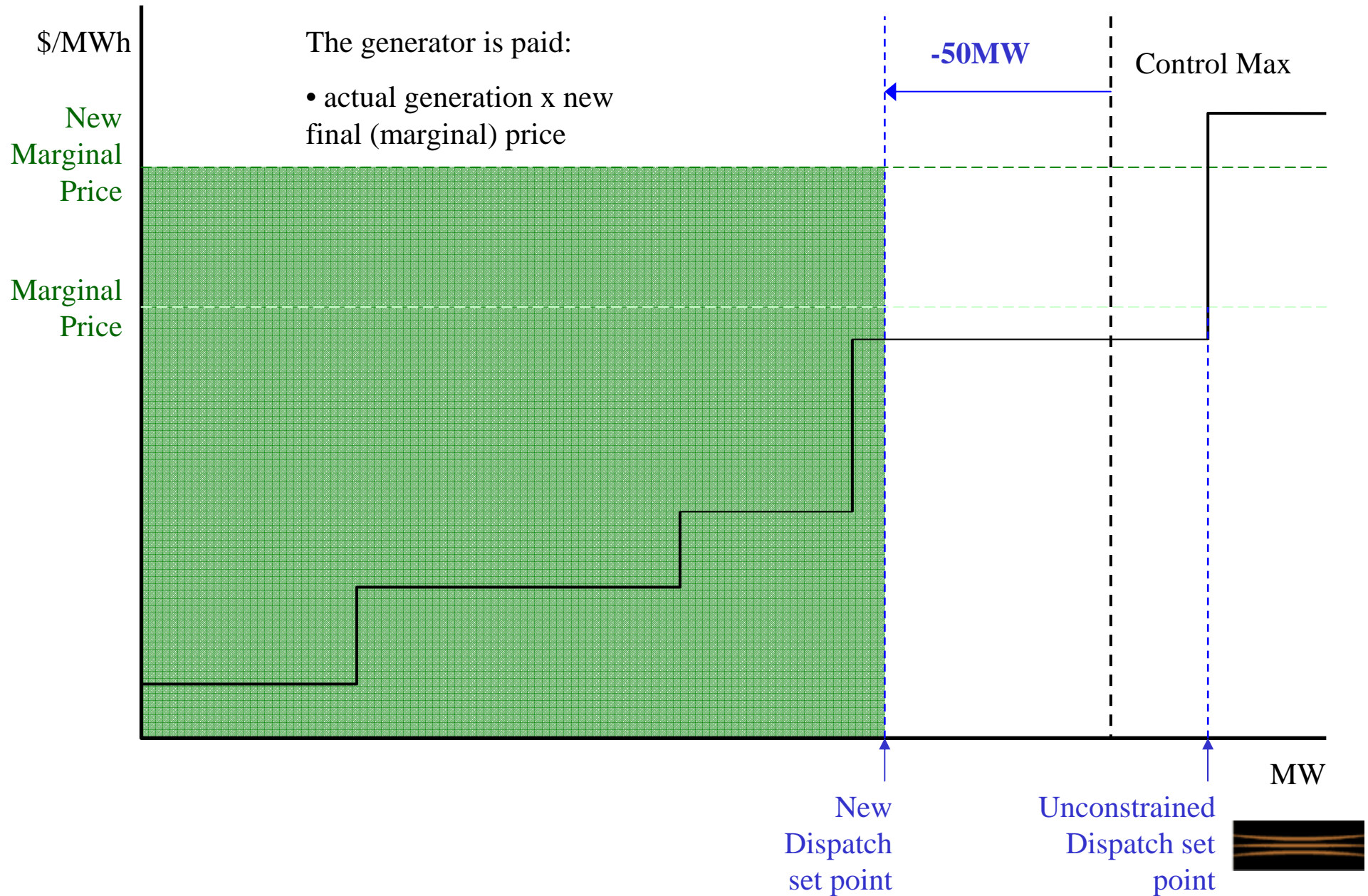
Control Max & Constrained Off (2)



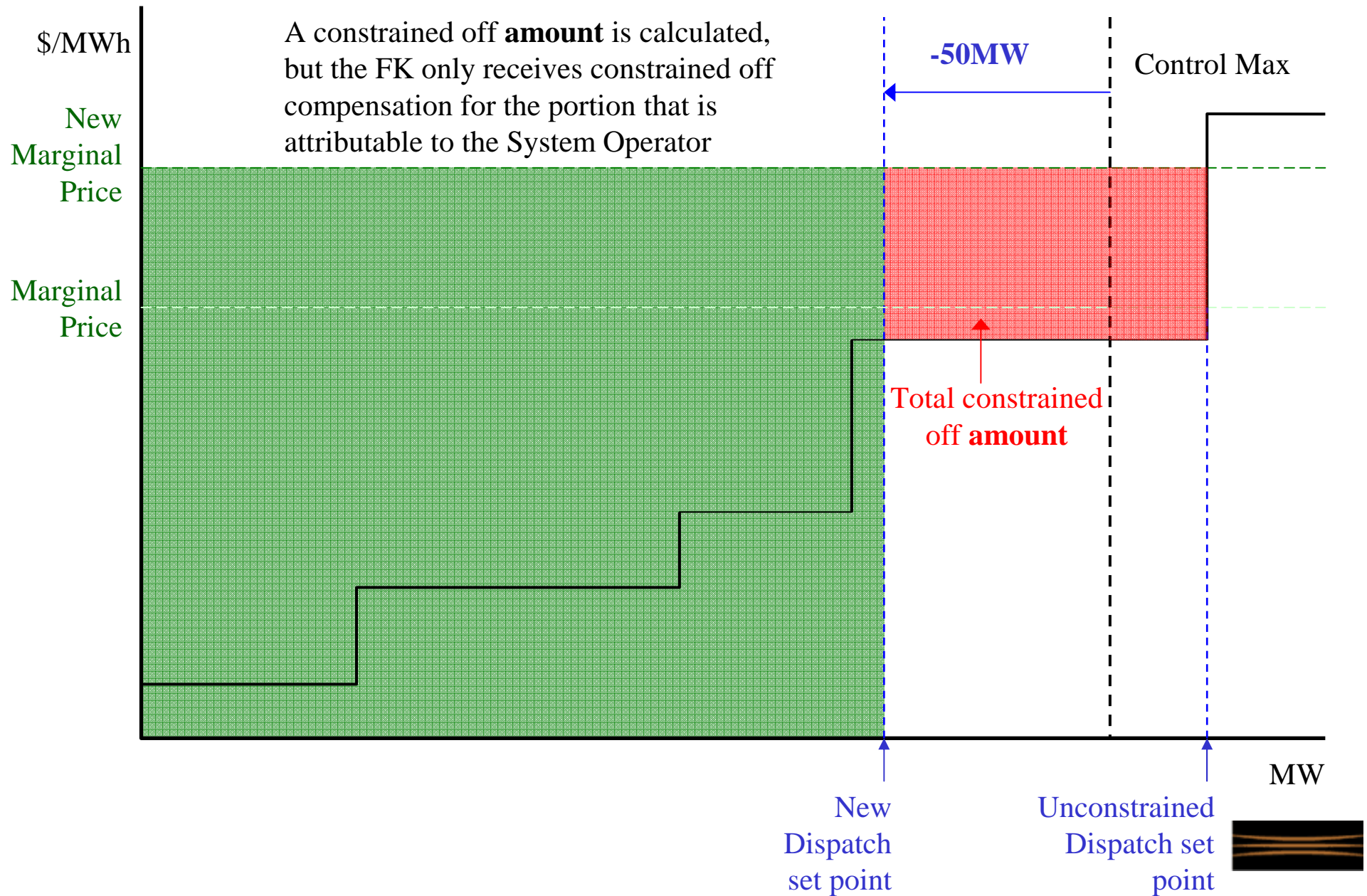
Control Max & Constrained Off (3)



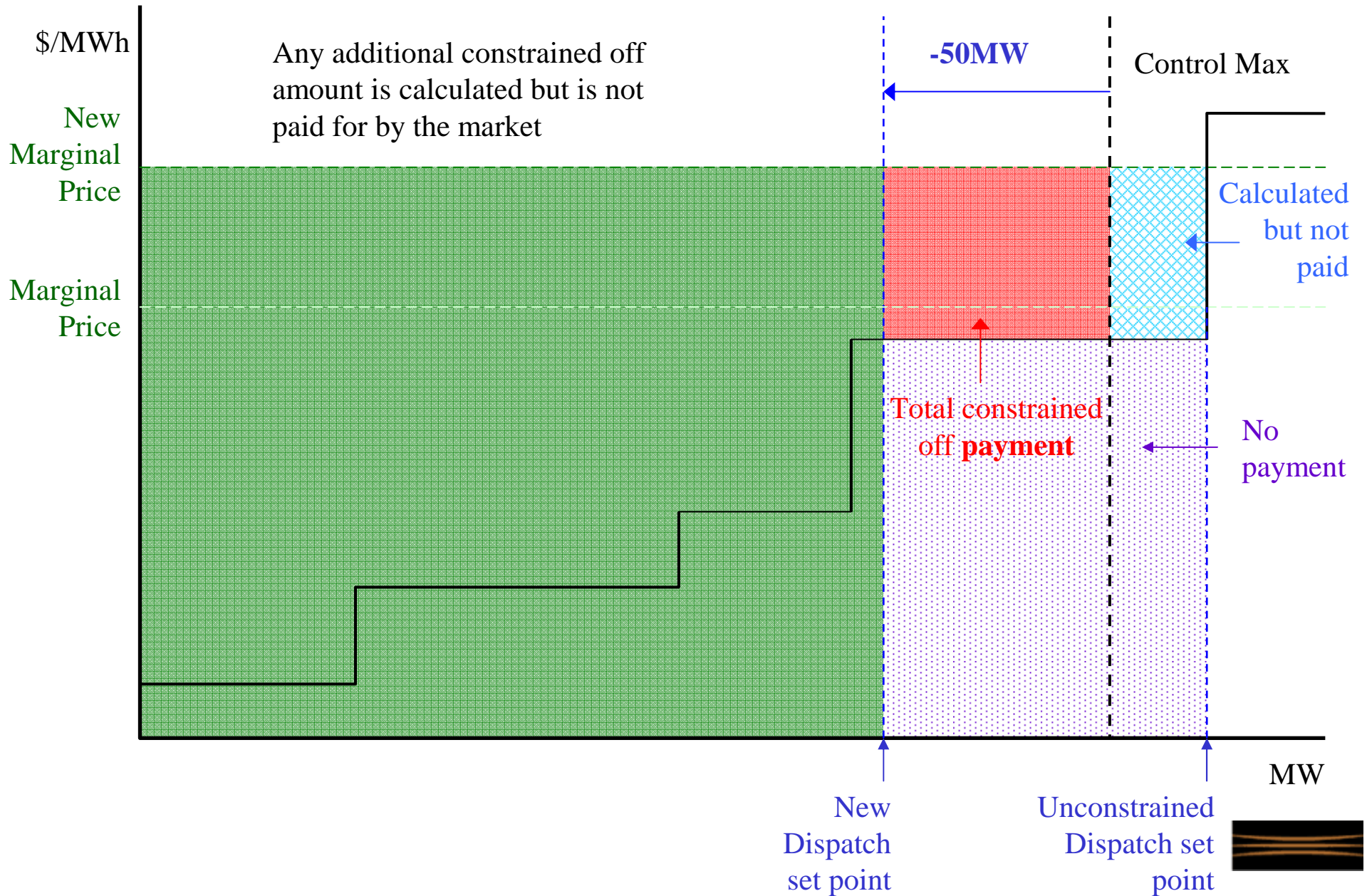
Control Max & Constrained Off (4)



Control Max & Constrained Off (5)



Control Max & Constrained Off (6)

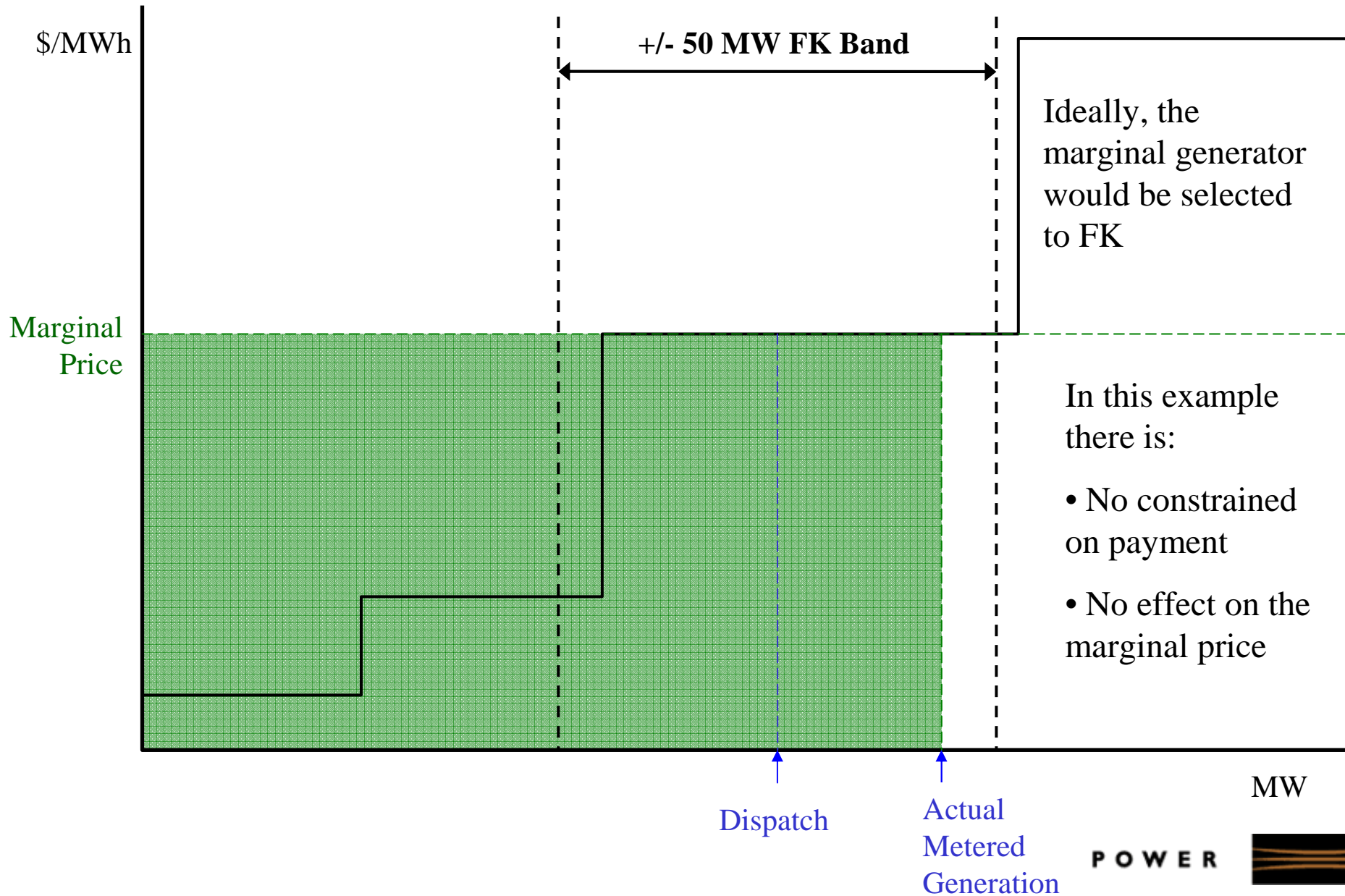


Allocation of FK payments

- Total constrained on and off amounts due to FK are calculated
- Constrained on and off amounts attributable to the System Operator (as a proportion of the total) are calculated
- The System Operator passes these payments on to purchasers (Part C Section IV Rule 11.4)
- Purchasers pay for the **total** constrained on amount
- Purchasers only end up paying for the proportion of constrained off payments that is attributable to the System Operator



Ideal FK Selection (1)

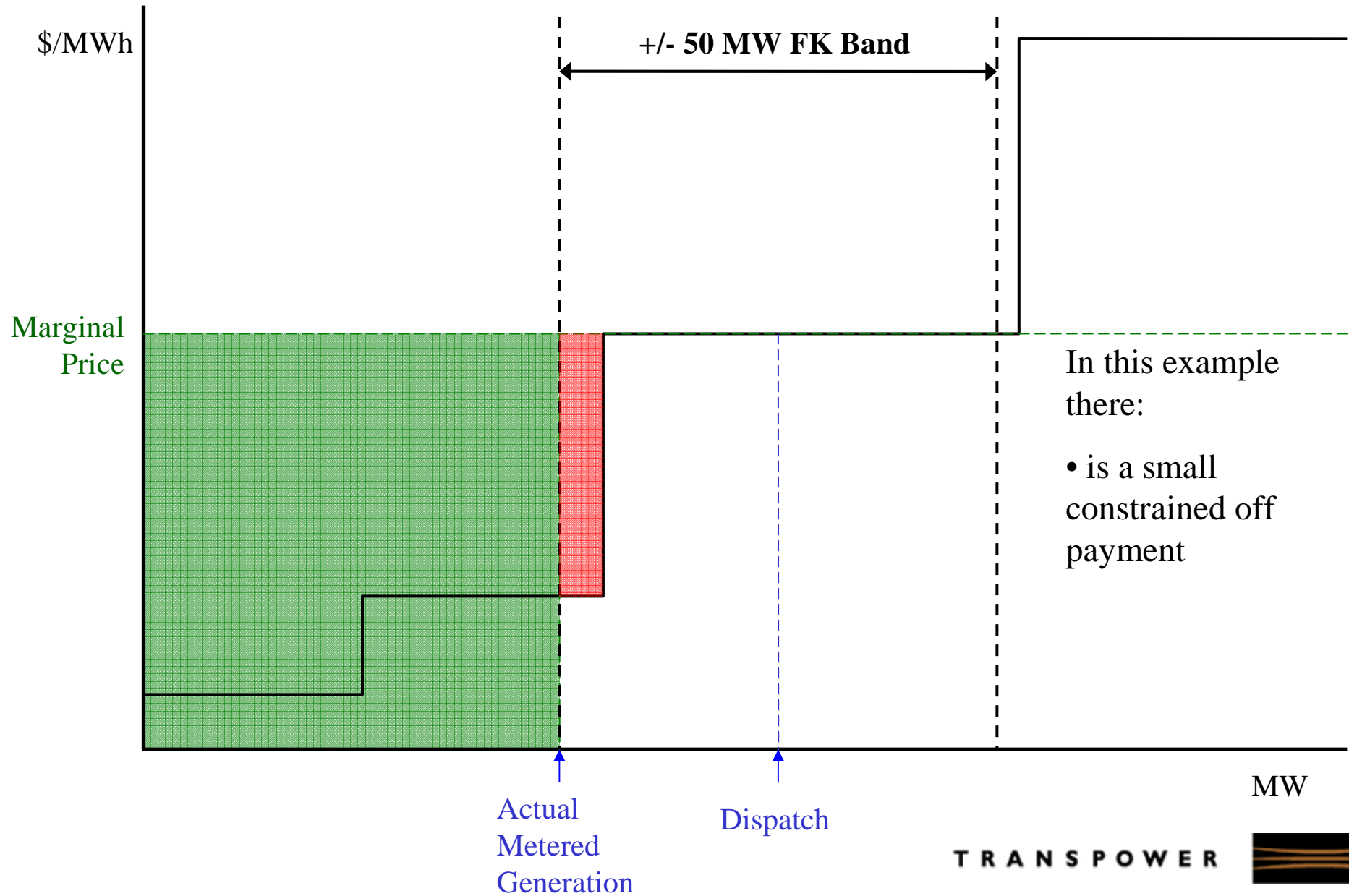


Ideally, the marginal generator would be selected to FK

- In this example there is:
- No constrained on payment
 - No effect on the marginal price



Ideal FK Selection (2)



Marginal Price Impact of FK Selection – Actual Example

- FK constrained on by 45 MW to meet dispatch set point (control min + offered bandwidth)
- This had the effect of **reducing** the North and South Island final reference prices by \$4.29 and \$3.63 respectively
- North and South Island load was 2794 MW and 1626 MW respectively, giving a total market impact of approximately \$8,944
- The FK received \$32,217 in constrained on payments for the trading period



Proposed changes due September 2005

- Incorporate calculation of constrained on for control minimum into Frequency Keeper selection
 - Subject to agreement by all four providers
- Only calculates costs to get to the Dispatch set point
 - Do not know where the Frequency Keeper will meter in the half-hour so cannot account for this
 - Has potential to reduce the large direct constrained on costs for the Control Minimum requirement



Implications of Constrained on/off

- Constrained on and off costs provide a signal of how far the FK is from the margin
- If you ignore constrained on and off costs, you ignore the effect on the marginal price
- If you get rid of constrained on and off payments FK providers may build constrained on and off costs into their offer cost to allow for being constrained from their control min or max **plus** the full +/- MW FK band operation all of the time



Summary

- Constrained on and off will occur by definition as a result of offering plant so that it is scheduled at the right level, given;
 - FK service
 - ramp rates
- Constrained on and off has to be considered in the calculations given the impact on marginal prices
- Constrained on is a variable cost, and can be a low cost when the deviation of metered energy from the dispatch point is small



The End



4.3 Clearing manager to calculate constrained off amounts

4.3.1 Generators

Notwithstanding rule 4.2, if a **constrained off situation** occurs during any **trading period** in the previous **billing period**, the **clearing manager** will calculate the **constrained off amounts** for each generator, for each affected price band, in accordance with the following formula:

$$\text{COF}_g = Q_{\text{cof}} * (P_f - P_o)$$

Where:

COF_g means the **constrained off amount** for a **generator**

Q_{cof} means the dispatched quantity in **MWh** (calculated as set out below) from that price band in the **offer** that was constrained off during a **trading period**, or the positive difference between the metered quantity and the scheduled quantity whichever is less

P_o means the price **offered** for that price band by that **generator** for the quantity of **electricity** from the **generating plant** which was constrained off;

P_f means the final price for that trading period at the **grid injection point**



4.3.3.3 Frequency Keeping

If the **system operator** has advised the **clearing manager** that a **frequency keeping** situation occurred in a **trading period** the **system operator** will be allocated a **constrained off amount** calculated in accordance with the following formula:

$$\text{SOCOFFK}_{\text{so}} = \text{TCOFP} * (\text{SOQcoffk} / \text{TQcoff})$$

Where:

$\text{SOCOFFK}_{\text{so}}$ means the **constrained off amount** attributable to the **system operator** for that **frequency keeping constrained off situation**

TCOFP means the total constrained off payment for that **trading period**;

SOQcoffk means the frequency keeping quantity that was advised to the **clearing manager** by the **system operator** pursuant to rule 4.9. of section III or the total quantity constrained off, whichever is the less; and

TQcoff means the total quantity constrained off



4.8 Generators do not get paid constrained off compensation

No **generator** will be entitled to be paid compensation in respect of any **constrained off situation** except as provided for in any **ancillary services arrangement** entered into between the **system operator** and the relevant **generator**. This rule will not affect any rights that any **participant** may have under these **rules** against the **system operator** for any failure by the **system operator** to comply with these **rules**.



5.3 Clearing manager to calculate constrained on amounts

If a **constrained on situation** occurred during any trading period during the previous **billing period**, then:

5.3.1 Calculation by clearing manager

The **clearing manager** will calculate the **constrained on amounts** for each generator for each affected price band in accordance with the following formula:

$$\text{COC} = Q_{\text{con}} * (P_o - P_f)$$

Where:

COC means the **constrained on amount** for a **generator**

Q_{con} means the dispatched quantity in **MWh** (calculated as set out below) from that price band in the **offer** that was constrained on during a **trading period**, or the positive difference between the metered quantity and the scheduled quantity whichever is less

P_f means the price **offered** for that price band by that **generator** for the quantity of **electricity** from the **generating plant** which was constrained on;

P_o means the final price for that trading period at the **grid injection point**



5.4.3 Frequency Keeping

If the **system operator** has advised the **clearing manager** that a **frequency keeping** situation occurred in a **trading period** the **system operator** will be allocated a **constrained on amount** calculated in accordance with the following formula:

$$\text{SOCONFK}_{\text{so}} = \text{TCOFP} * (\text{SOQconfk} / \text{TQcon})$$

Where:

$\text{SOCONFK}_{\text{so}}$ means the **constrained on amount** attributable to the **system operator** for that **frequency keeping constrained on situation**

TCOFP means the total constrained on payment for that **trading period**;

SOQconfk means the frequency keeping quantity that was advised to the **clearing manager** by the **system operator** pursuant to rule 4.9. of section III or the total quantity constrained on, whichever is the less; and

TQcon means the total quantity constrained on



6.5 Clearing manager to calculate amounts payable

The **clearing manager** will calculate and invoice **purchasers** for **constrained on compensation** for each **trading period** in accordance with the following formula:

$$\text{COC}_p = (\text{COC}_g - \text{COC}_{\text{SO}}) * (P_q / \text{TP}_q)$$

Where:

- COC_p means the **constrained on compensation** payable by a **purchaser**;
- COC_g means the sum of constrained on compensation owing to generators injecting electricity for that **trading period** calculated in accordance with rule 5.3;
- COC_{SO} means any **constrained on amount** for that **trading period** payable by the **system operator** to that **generator** pursuant to rule 6.2;
- P_q means the total **electricity** purchased by that **purchaser** from the **clearing manager** during the **trading period** as shown by the **reconciliation information** calculated by the **reconciliation manager** pursuant to section VI; and
- TP_q means the total **electricity** purchased by all **purchasers** from the **clearing manager** during the **trading period** as shown by **reconciliation information** calculated by the **reconciliation manager** pursuant to section VI.



11.4 Frequency keeping costs are allocated to purchasers

The **allocable cost of frequency keeping** will be paid by **purchasers** to the **system operator** in accordance with the process in rule 11.7. These costs will be calculated in accordance with the following formula:

$$\text{Share}_{\text{PURx}} = \frac{\text{Fc} * \max(0, \sum_t (\text{Offtake}_{\text{PURxt}} - E^{\text{FK}}_{\text{PURxt}}))}{\sum_x \max(0, \sum_t (\text{Offtake}_{\text{PURxt}} - E^{\text{FK}}_{\text{PURxt}}))}$$

Where:

$\text{Share}_{\text{PURx}}$

is **purchaser x's share of allocable cost** in relation to **frequency keeping**;

Fc

is the **allocable cost of frequency keeping** services in the **billing period**;

$\text{Offtake}_{\text{PURxt}}$

is the total **reconciled quantity in kWh** for **purchaser x** across all **grid exit points** in **trading period t** in the **billing period**;

$E^{\text{FK}}_{\text{PURxt}}$

is the quantity of any **frequency keeping** provided pursuant to any alternative **ancillary services arrangement for frequency keeping** authorised by the **system operator** for **purchaser x** in **trading period t**

