Non-uniform pricing and thermal orders for the day-ahead Market

PCR Stakeholder forum

Brussels, January 11, 2016

Pricing: the current design

Which requirements are concerned? Blocks, smart orders (and potentially also the price intuitiveness requirement)

The current design imposes strict linear pricing, hence solutions cannot have paradoxically accepted orders. Consequently:

Loss of welfare

Blocks can be accepted paradoxically in welfare maximizing solutions

Fairness issue

Rejecting deep in-the-money orders

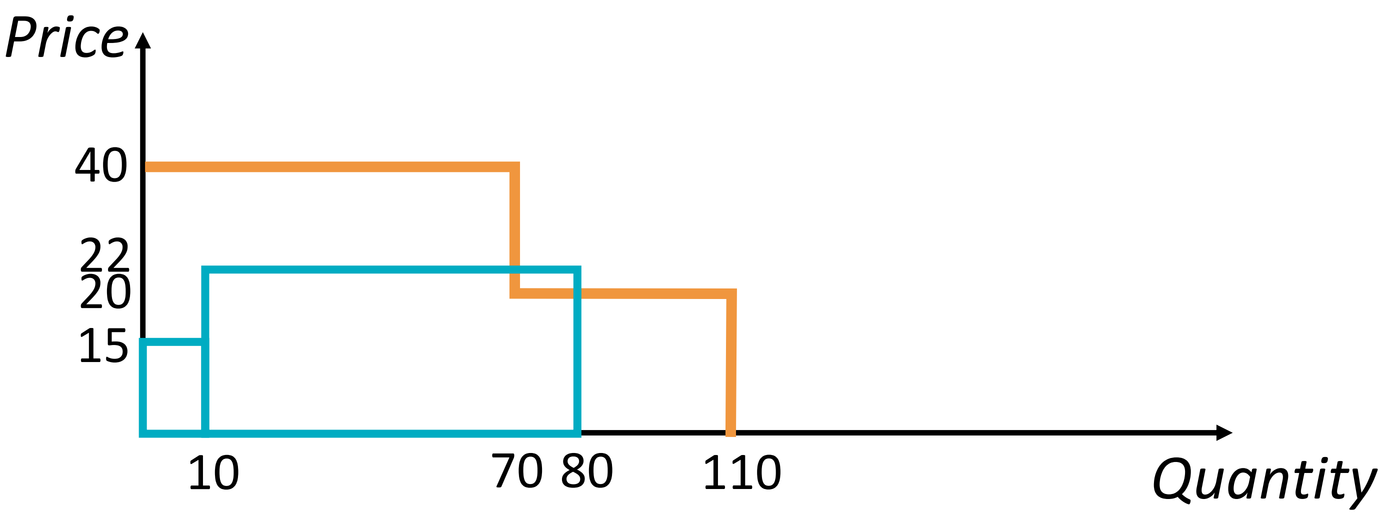
Performance and transparency issue

We sometimes find suboptimal solutions which may contain wrong PRBs (time restriction)

We propose and illustrate a "new" approach to mitigate these issues. It is Based on Mathieu Van Vyve's article: *Linear prices for non-convex electricity markets: models and algorithms.*

Let us start with an example with blocks

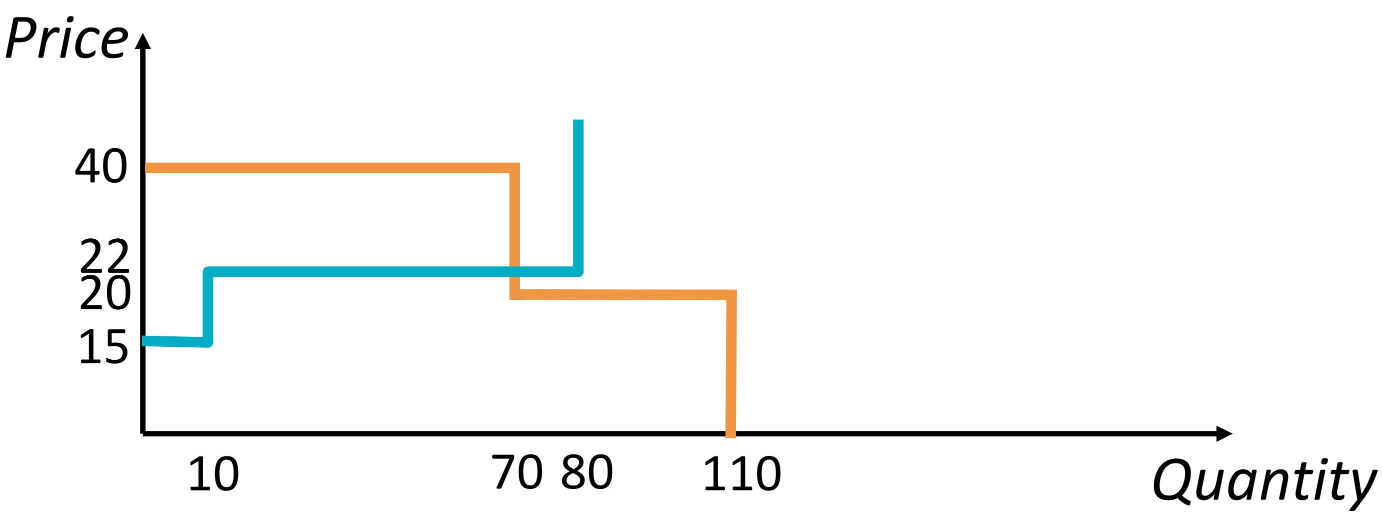
	Type	Quantity [MWh]	Price [EUR/MWh]
Block 1	Supply	10	15
Block 2	Supply	70	22
Step 3	Demand	-70	40
Step 4	Demand	-40	20



Consider first that blocks are step orders

Market price = 22 EUR/MWh

Welfare = 70*40-10*15-60*22 = 1330 EUR

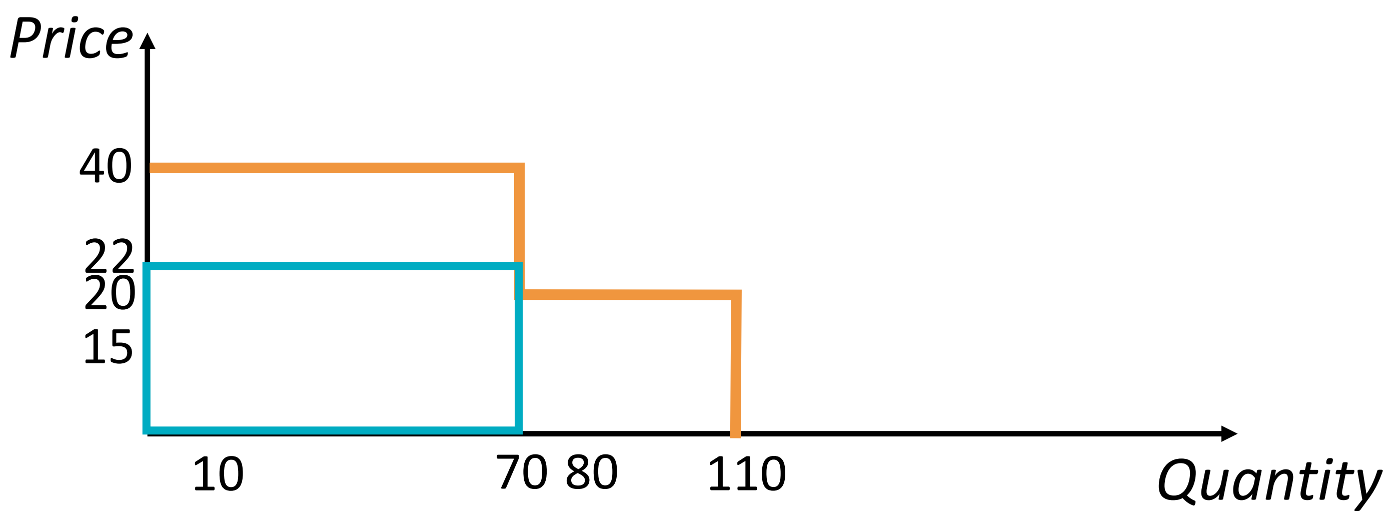


This solution is not feasible, but this is the highest welfare we can achieve

Optimal solution, output by Euphemia if block 1 can be rejected (cf. next slide)

Reject block 1, accept block 2

Welfare = 70*40-70*22 = 1260 EUR

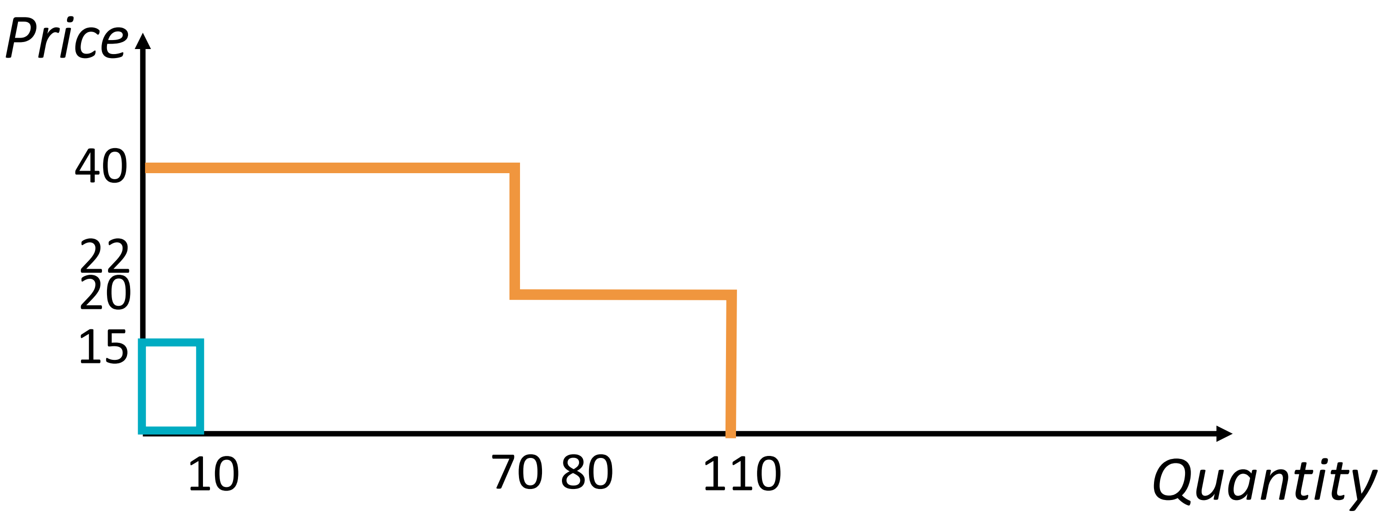


But block 1 was deep in the money!

Solution output by Euphemia if the delta P rule prevents rejecting block 1

Reject block 2, accept block 1

Welfare = 250 EUR

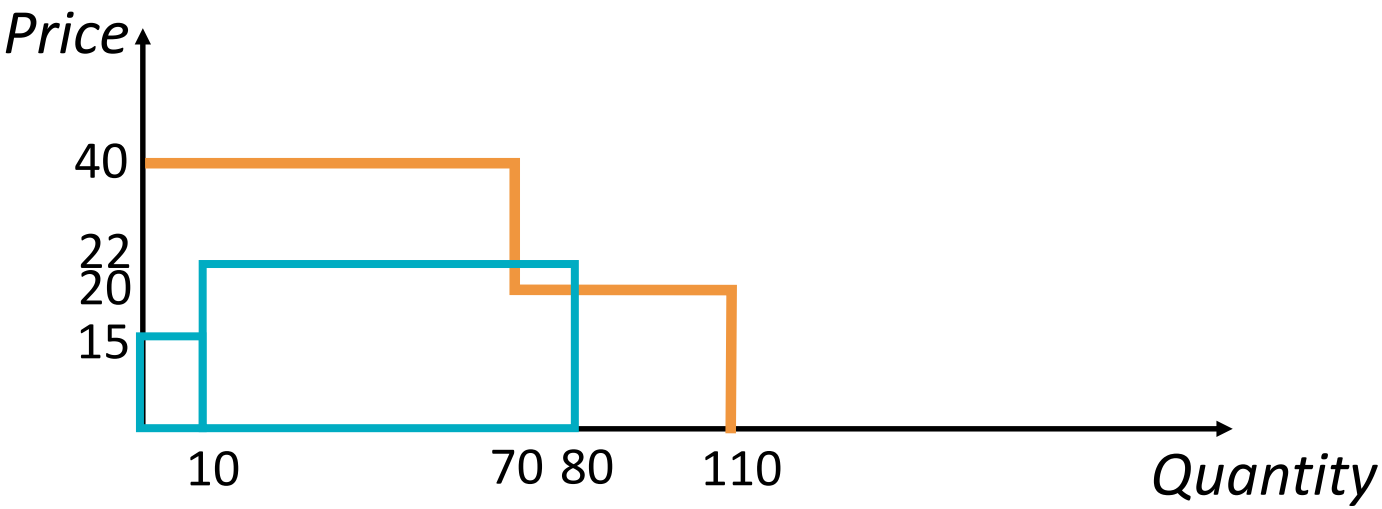


Highly suboptimal!

A new proposal

Accept block 1 and block 2.

Welfare = 70*40+10*20-10*15-70*22 = 1310 EUR



But there does not exist a strict linear price

A new proposal: two-step approach

1. Solve the primal problem to optimality (!)

2. Compute a price and some ***uplifts*** to compensate accepted out-of-the-money orders:

Uplift of order *i*

Minimize maximum uplift

$$\min_{\lambda, u} \quad \lambda$$

$$\text{s.t.} \quad u_i \leq \lambda \quad \forall i$$

Market price

Reach financial balance

$$\sum_i |Q_i x_i^\star| u_i = 0$$

Bound the uplift

$$|Q_i x_i^\star| u_i \leq Q_i x_i^\star p - P_i Q_i x_i^\star \quad \forall i$$

Income-Welfare

Applied to our example

$$\min_{\lambda, u} \quad \lambda$$
$$\text{s.t.} \quad u_i \leq \lambda \; 8i$$
$$10u_1 + 70u_2 + 70u_3 + 10u_4 = 0$$
$$u_1 \leq p - 15$$
$$u_2 \leq p - 22$$
$$u_3 \leq 40 - p$$
$$u_4 \leq 20 - p$$

Solution:

$u_1 = u_2 = u_3 = 0.143$ *EUR/MWh*

$u_4 = -2.143$ *EUR/MWh*

$p = 22.143$ *EUR/MWh*

Interpretation:

Order 1 is remunerated at 22 *EUR/MWh*

Order 2 is remunerated at *22 EUR/MWh*

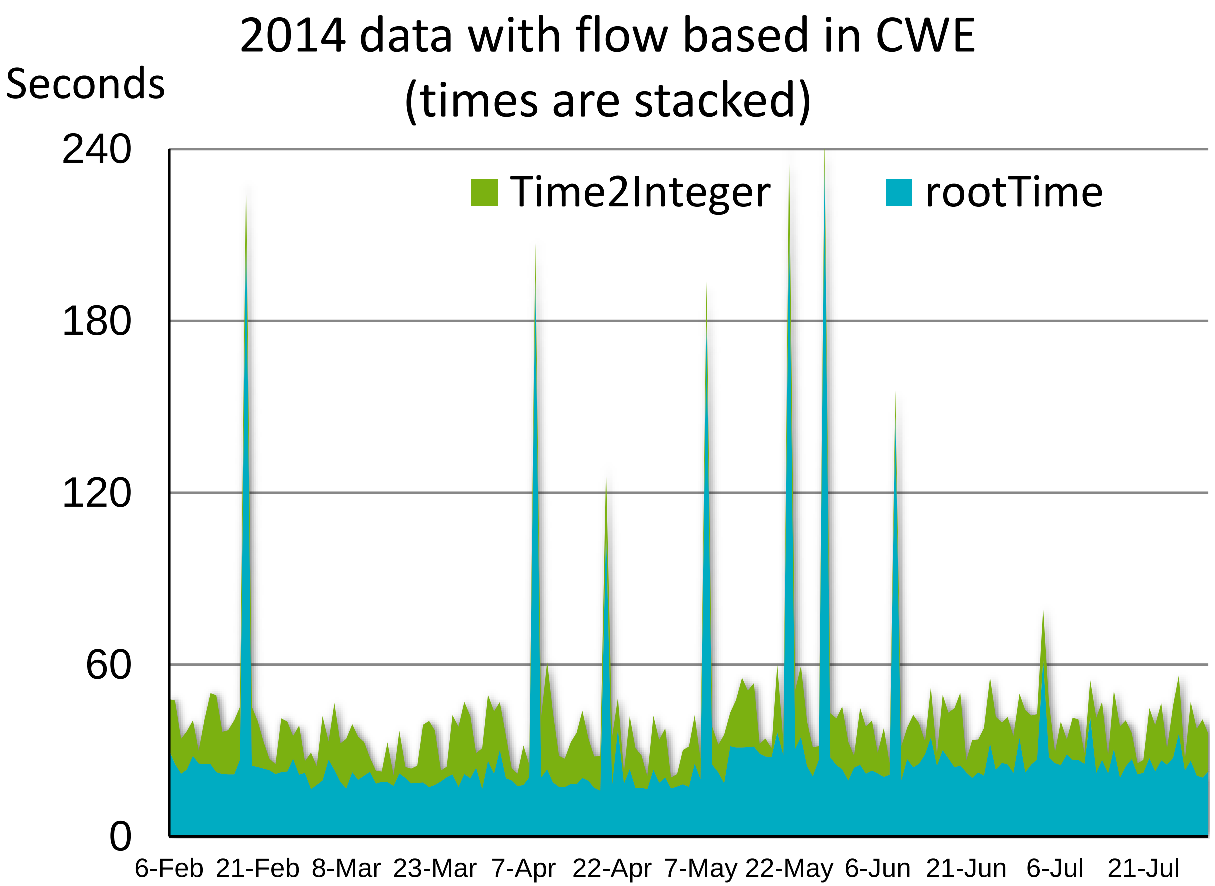
Order 3 pays *22.286 EUR/MWh*

Order 4 pays *20 EUR/MWh*

Properties of the new proposal

- More transparent: we can prove optimality more easily
- More welfare than with the current pricing rule
- All orders contribute to the uplift until they are at-the-money
- No missing money issue
- Greatly simplifies the algorithm design
  - We can use all the power of modern solvers (cf. next slide)
  - Hence opportunity for more elaborate order types, e.g. thermal orders (cf. next section)

For the first step, the time to optimality is currently on average of 44 seconds



What makes it so fast?

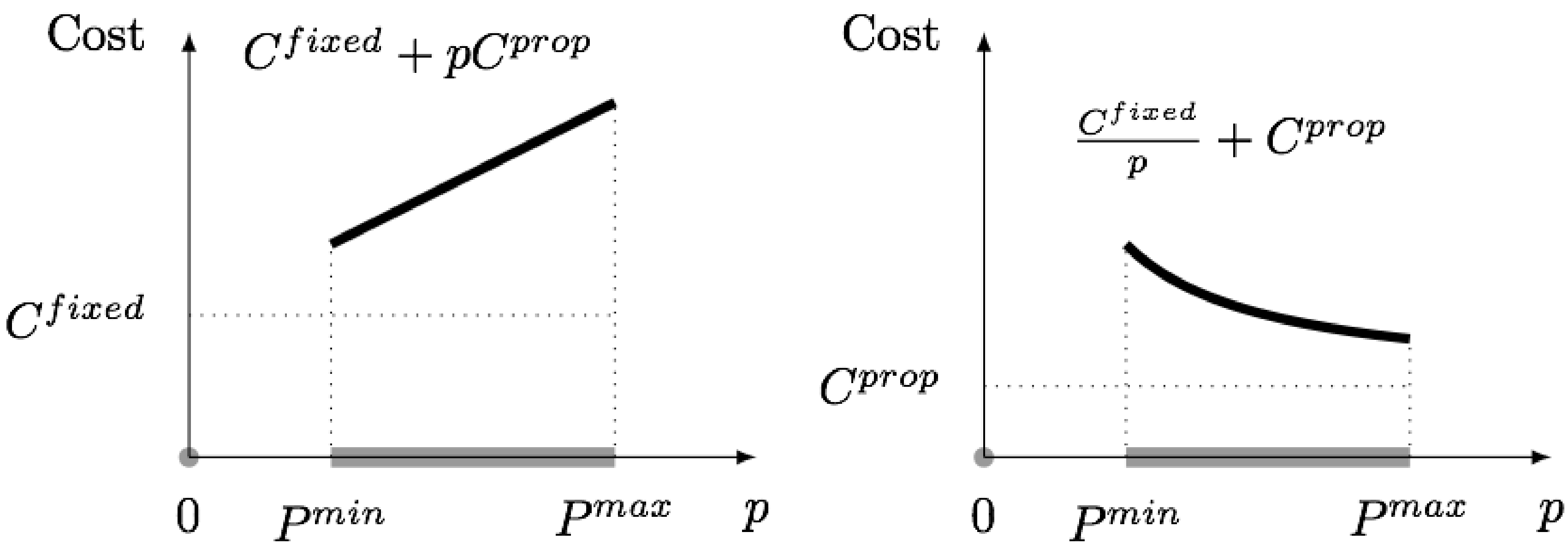
- CPLEX MIP preprocessing
- CPLEX heuristics
- Multithreading (not used in this experiment)

A new “Thermal order”

- Model a thermal unit
  - Variable cost expressed in €/MWh of the thermal order (cf. next slide);
  - Start up profile and cost (similar to MIC fixed term) (cf. next slide);
  - Minimum stable generation (similar to minimum acceptance ratio)
  - Load gradient (similar to complex orders)
  - Minimum running time when started, minimum down time
  - Shut down profile (similar to scheduled stop)
  - Must run conditions (capacity not available to the market)
  - Flexible in time (similar to exclusive groups)
- Could thus generalize (curtailable) block orders, exclusive groups, and complex orders
- Would be much easier to specify for market participants

Pricing

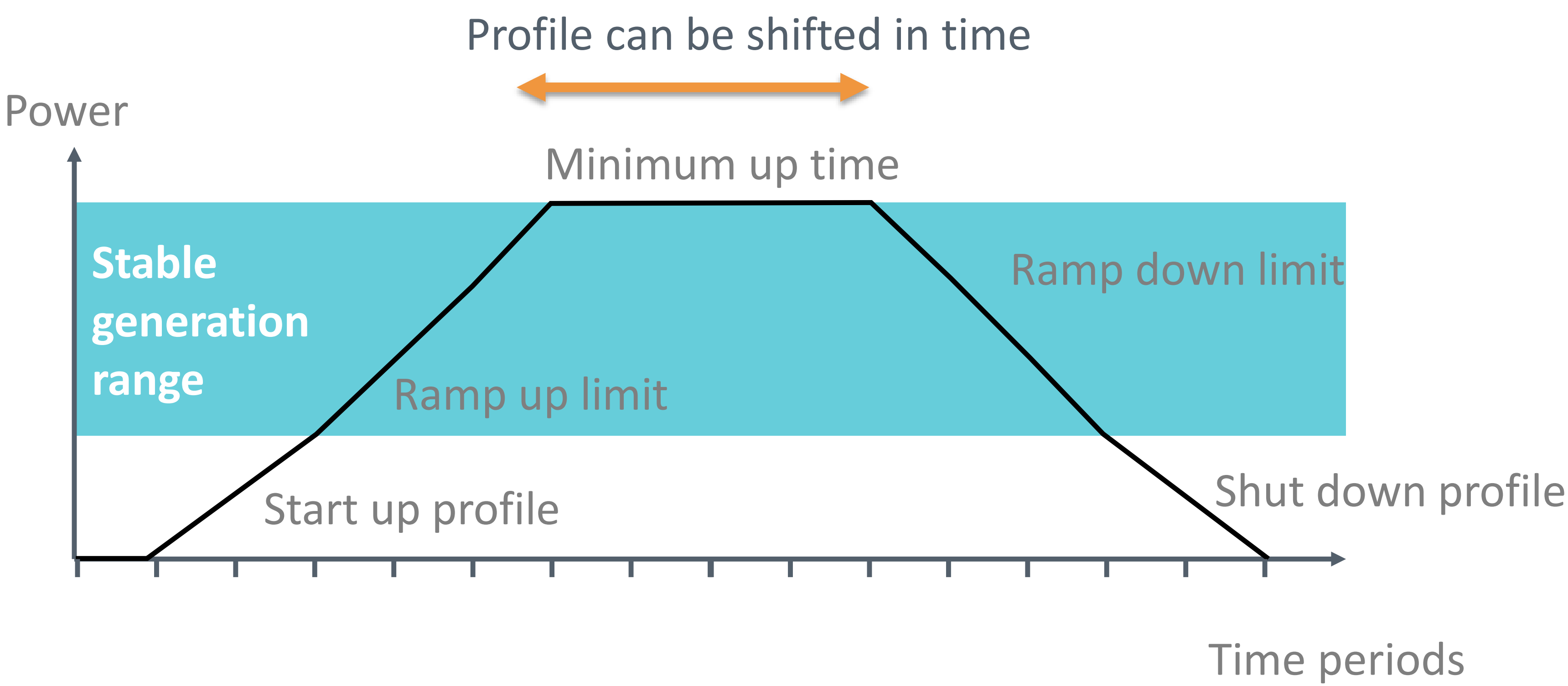
A fixed cost when the machine is on plus a variable cost



(a) Cost per hour.

(b) Cost per Mega Watt hour.

Graphical definition



Thank you !

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