2015_ST03_Verron.pdf

The challenges associated with emission ceilings based on multivariate quantile

Thomas Verron, Xavier Bry*, Xavier Cahours, Stephane Colard.

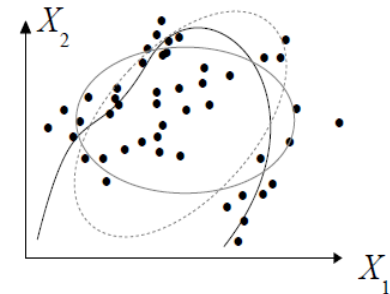*UM2, University Montpellier 2, France*

Summary

- The problem of constituent limitations

  - Context
  - How to deal with one constituent?
  - Is it generalizable for several constituents?

- Building up rules for multiple constituent limitations

  - Prioritisation
  - Compensation
  - Domination

The problem

Context

Main issue:

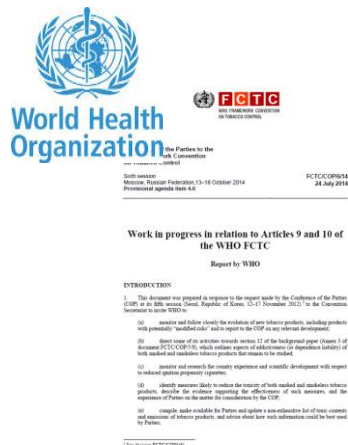limiting the quantity of certain constituents in smoke through banning-type rules

Table 3. Toxicants recommended for mandated lowering

Toxicant	Level in µg/mg nicotine		Value
	International brands[a]	Canadian brands[b]	
NNK	0.072	0.047	Median of data set
NNN	0.114	0.027	Median of data set
Acetaldehyde	860	670	125% of median of data set
Acrolein	83	97	125% of median of data set
Benzene	48	50	125% of median of data set
Benzo[a]pyrene	0.011	0.011	125% of median of data set
1,3-Butadiene	67	53	125% of median of data set
Carbon monoxide	18400	15400	125% of median of data set
Formaldehyde	47	97	125% of median of data set

NNK, 4-(N-nitrosomethylamino)-1-(3-pyridyl)-1-butanone; NNN, N'-nitrosonornicotine

[a] Based on data from Counts et al., 2005

[b] Based on the data reported to Health Canada minus brands with levels of NNN per mg nicotine > 0.1 ng, which eliminates most US and Gaulouise brands. (http://www.hc-sc.gc.ca/hl-vs/tobac-tabac/legislation/reg/indust/constitu_e.html)

Constraint:

Take into account the complexity of the products on the market such as inter-relationships between constituents and the consequences of existing regulations (excluding already a large number of products)

Conference of the Parties to the WHO Framework Convention on Tobacco Control
Sixth session Moscow, Russian Federation,13–18 October 2014. **FCTC/COP/6/14 24 July 2014**

Two aspects of the constraint

Clarity

Which characteristics of banned products should be considered ? Can this be advocated?
How to define the limits and which rules of decision to reject or accept products?

Feasibility

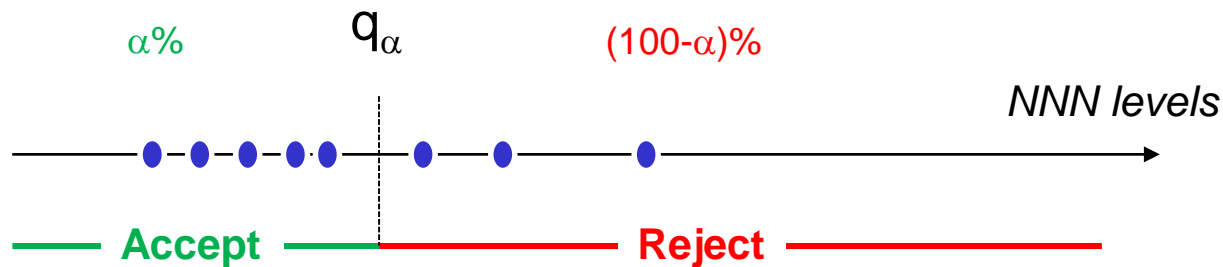How to control the proportion of products that the rule will ban?

One constituent

Clarity

To regulate one constituent (for instance NNN), the only one possibility consists to define a limit and to reject all products with a level above this limit.

Feasibility

To keep α% of the products, the limit must be a q_α-quantile

α% q_α (100-α)%

NNN levels

Accept —— **Reject** ——

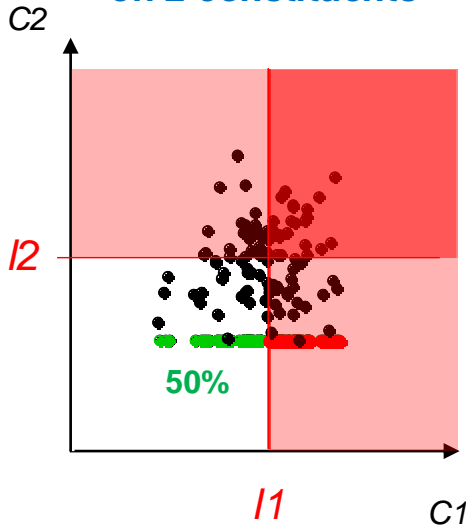**Can we generalise to multi-constituents?**

More than one constituent

Clarity of the rule:

To regulate independently several constituents, a lot of decision rules exist (no uniqueness of the rules).
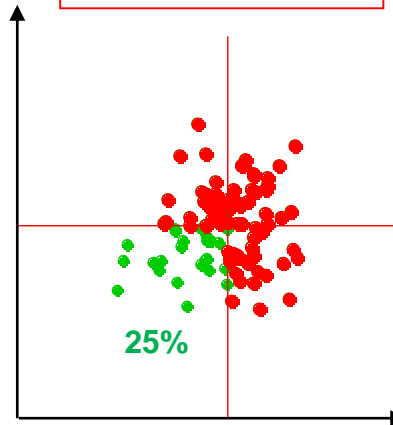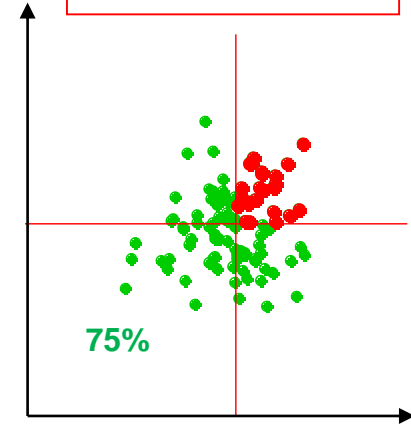
Multi ceiling based on *2 constituents*

50%
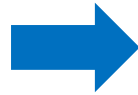
Rejected if:
$C1 > I1$ OR $C2 > I2$

25%

A product is rejected if at least 1 of the constituents exceed his limit

Rejected if:
$C1 > I1$ AND $C2 > I2$

75%

A product is rejected if the 2 constituents exceed their limits

Multiple ceilings based on K constituents

A product is rejected if at least k of the constituents exceed the limit. With k in $\{1,\ldots, K\}$

More than one constituent

Feasibility of the rule:
Becomes tricky, because the proportion of the banned products depends dramatically on an interaction of the rule and the statistical dependencies between constituents

Multi ceiling based on 2 constituents
With the rule at least one constituent exceed his limit

Formaldehyde vs NNN*

Feasibility of the rule

For instance keep
50% of the products

49%

Very high
dependency

25%

Very low
dependency

17%

Real situation

Impossible to master the proportion of products that the rule will ban.

*Counts ME & al. Smoke composition and predicting relationships for international commercial cigarettes smoked with three machine-smoking conditions. Regul Toxicol Pharmacol 2005;41:185–227.

More than one constituent

Feasibility of the rule:

Becomes tricky, because the proportion of the banned products depends dramatically on an interaction of the rule and the statistical dependencies between constituents

Multi ceiling based on 2 constituents
With the rule the two constituent exceed their limits

Formaldehyde vs NNN*

Feasibility of the rule

For instance keep 50% of the products

50%

Very high dependency

75%

Very low dependency

84%

Real situation

➡ Impossible to master the proportion of products that the rule will ban.

*Counts ME & al. Smoke composition and predicting relationships for international commercial cigarettes smoked with three machine-smoking conditions. Regul Toxicol Pharmacol 2005;41:185–227.

Summary part 1:

Over one constituent, the approaches that do not consider the dependency patterns between constituents **fail to define robust rules**:

The constraints of clarity and feasibility are not satisfied.

As a consequence, it is very difficult to anticipate the impact of such rules on commercial products and a market*.
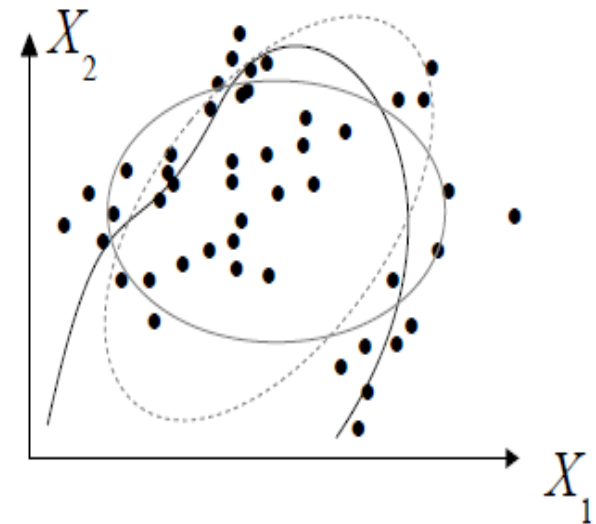
As show by X. Cahours et al, up to 86% products would be rejected using the rules suggested by WHO*

Building up rules for multiple constituent-limitation

* Product Compliance Mapping CORESTA 2012 Sapporo

Building up rules for multiple constituent-limitation

1. Prioritisation
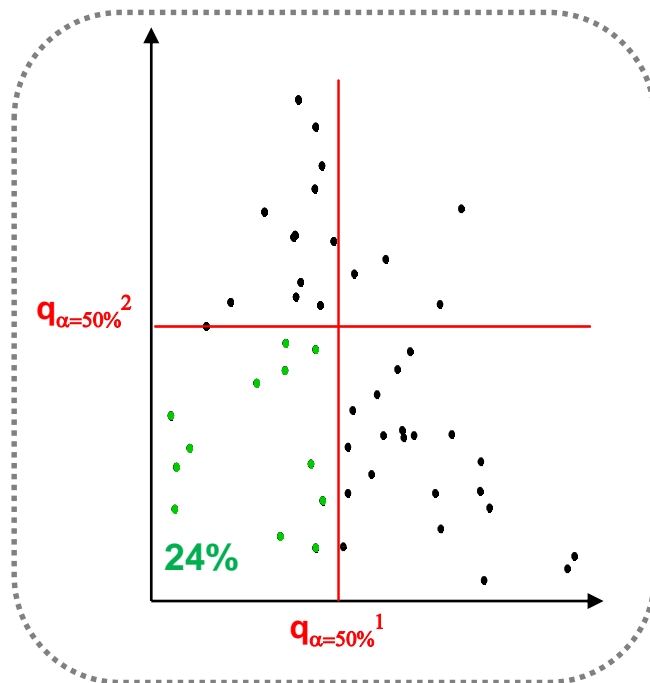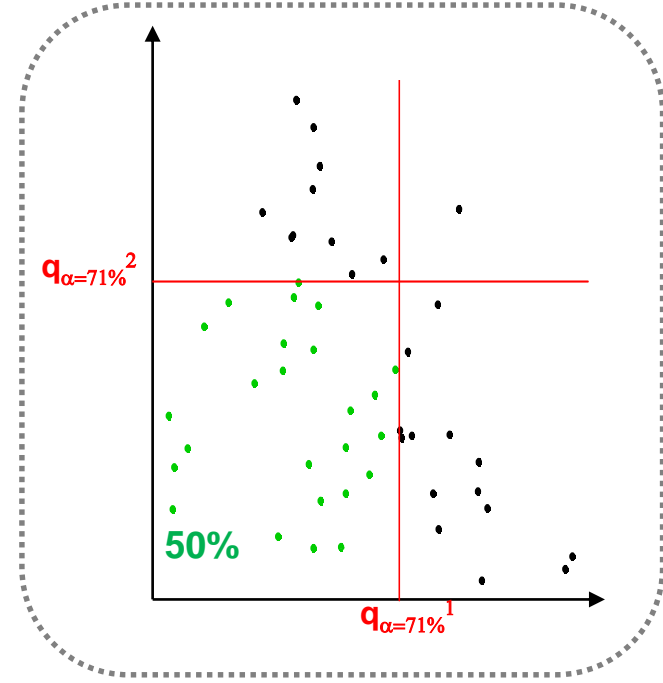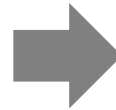2. Compensation
3. Domination

Prioritisation

Operation: Perform limitation following a hierarchical process.

Algorithm

Compute the quantile q_α^1 for the first priority constituent
For i in 2 to K
    Keep all products lower the quantile q_α^{i-1}
    Compute the quantile q_α^i for the second priority constituent

To keep α % products re-adjust quantile to

$$\alpha^{\frac{1}{K}} \; (0.5^{\frac{1}{2}} = 0.71)$$

$q_{\alpha=50\%}^2$

$q_{\alpha=50\%}^1$

24%

$q_{\alpha=71\%}^2$

$q_{\alpha=71\%}^1$

50%

Limitations: What hierarchy between constituents ? Asymmetric treatment =>depend on hierarchy.

Compensation

Operation: Perform a linear compensation

Algorithm

Aggregating constituents through an a priori formula:

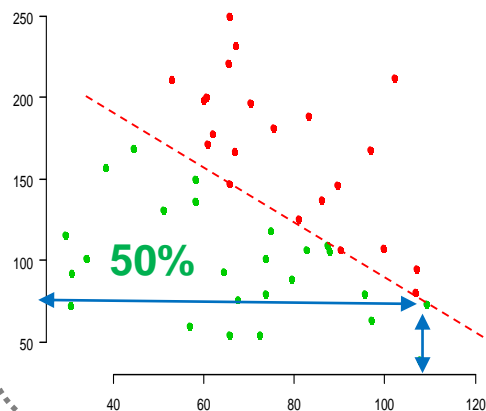$$\emptyset_a = \left(\sum_k \pi_k \, (x_k)^a \right)^{\frac{1}{a}}$$

← *Variable that conditions the rejection area*
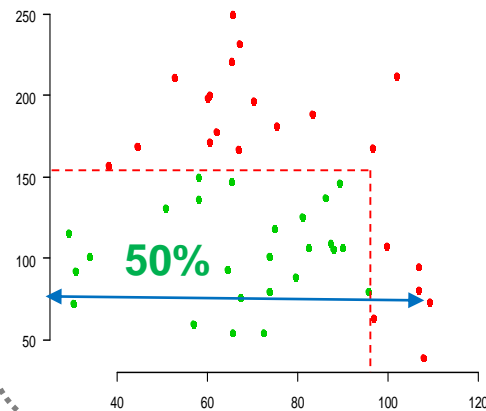
Constituent k

Weight of constituent k

a = 1
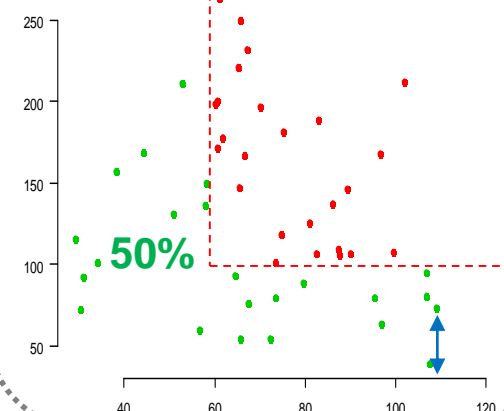$\emptyset_1$ = classical average
No priority = compensation

50%

a → +∞
$\emptyset_{+\infty} = \max(\pi_k \, (x_k)^a)$
Priority given to high levels

50%

a → -∞
$\emptyset_{-\infty} = \min(\pi_k \, (x_k)^a)$
Priority given to low levels

50%

Limitations: choice of the standardisation and tuneable parameters (power, weight)
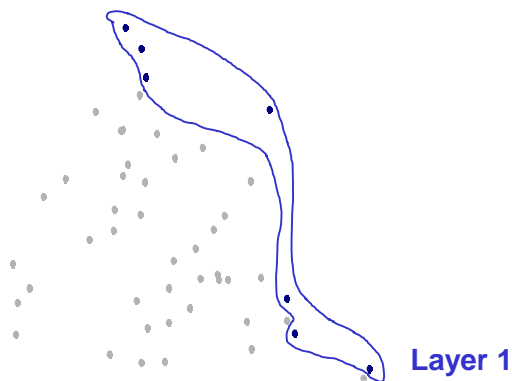
Domination

Operation: Perform a layer-method based on a domination criterion

Definition

A product *a* (strictly) dominates another *b* if it has greater or equal values for *all* constituents, and strictly greater for at least one constituent.

Algorithm

Layer 1 (top of order) consists of all products that are strictly dominated by *no other*
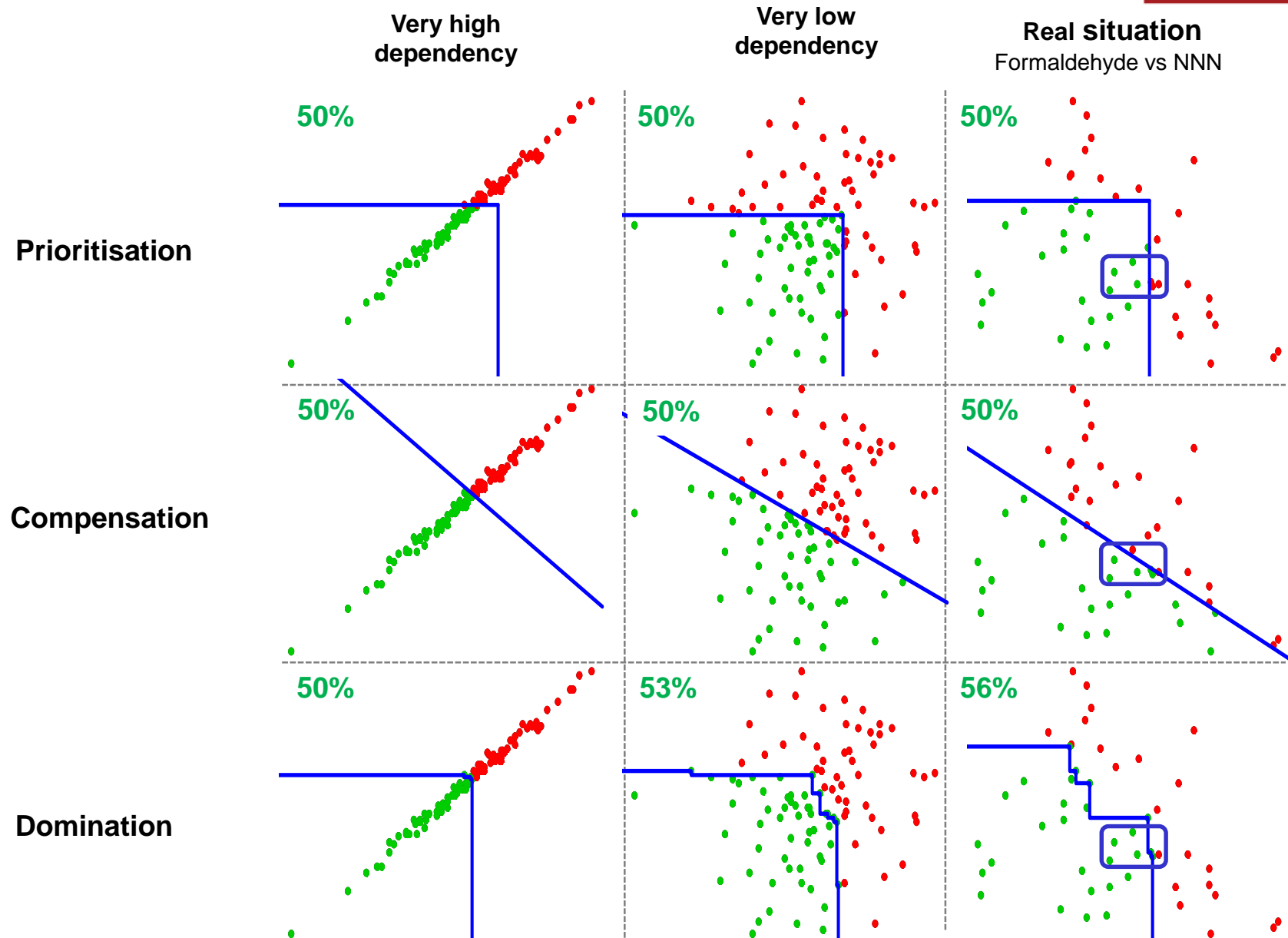Each subsequent consists of all points that are strictly dominated by some products of former layers *only*.

Layer 1

Repeat the process

56%
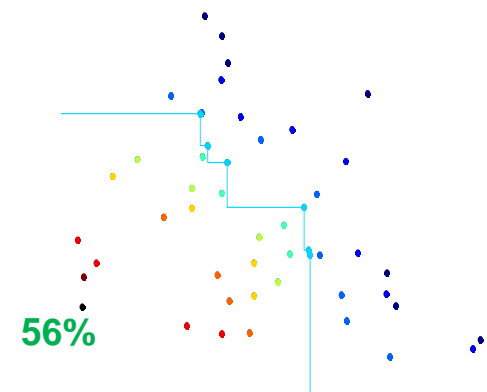
Limitations: Sensitive to the number of constituents. Too many constituents would lead to a lack of domination.

Application

What did we learn?

Need
to consider the complexity of the products on the market and the dependency patterns between constituents to define appropriate decision rules

Must
use multidimensional approaches

Have
some limitations:
- Acceptation or rejection of products depends on the decision rules
- Interpretation of product decision can be difficult
- An increase of the number of constituents to regulate reduces the feasibility of the rules

BUT
Beyond simply reducing the number of products on a market, the purpose and benefit of rejection should be defined first.

CORESTA SSPT 2015
CORESTA Smoke Science & Product Technology

너의 주의를 위해 너를 감사하십시요

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