



BE  MART

Together for Active and Efficient Buildings



The BE-Smart project has received funding from The European Union's Horizon 2020 research and innovation programme under grant agreement No 818009.



Multifunctional EPoGs - Colour and multi-functionality

1. Aesthetically attractive and reliable Energy Positive Glazing (EPoG).

2. Evaluate and develop colouring solutions

3. Multi-functionality





Aesthetically attractive and reliable Energy Positive Glazing (EPoG)

Standard c-Si modules



Typical ground installation



Typical building installation



- Market share of Si wafer-based PV modules in 2020: > 95%
- Appearance: dark blue to black colour, standard unit dimensions



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Aesthetically attractive and reliable Energy Positive Glazing (EPoG)

Standard c-Si modules



Typical building installation



Multi-functional EPoG elements



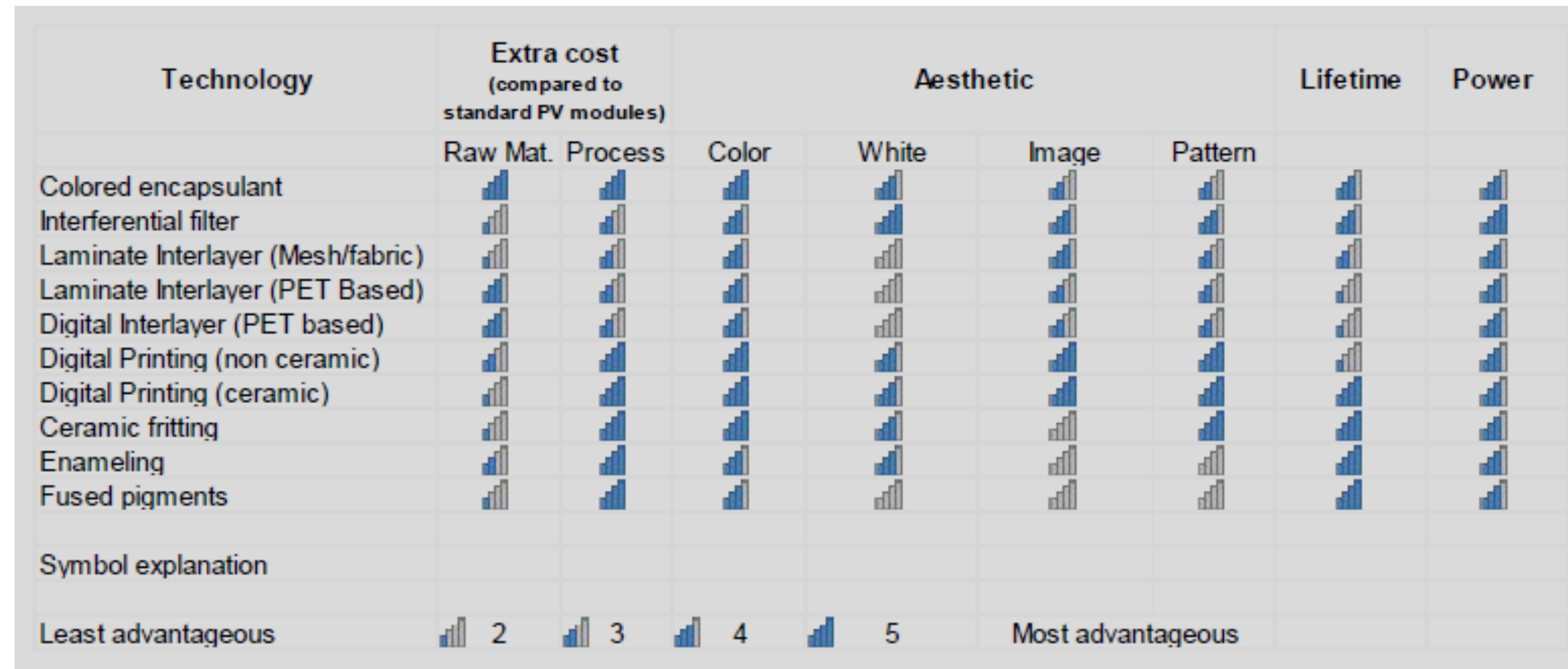
- Multiple module colours, patterns/images possible;
- Multiple module dimensions;
- Multi-functions: thermal insulation, acoustic barrier, Surface self-cleaning, Self-heating



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Comparison on the currently available colouring techniques for EPoGs



- Wide range of selections with pros and cons of each;
- Selection of colouring techniques depends on the specific needs of the project;
- Cost should be considered within the scope of the total EPoG system cost



Examples of colour development in Be-smart

Coloured enamelled glass

Coloured encapsulant

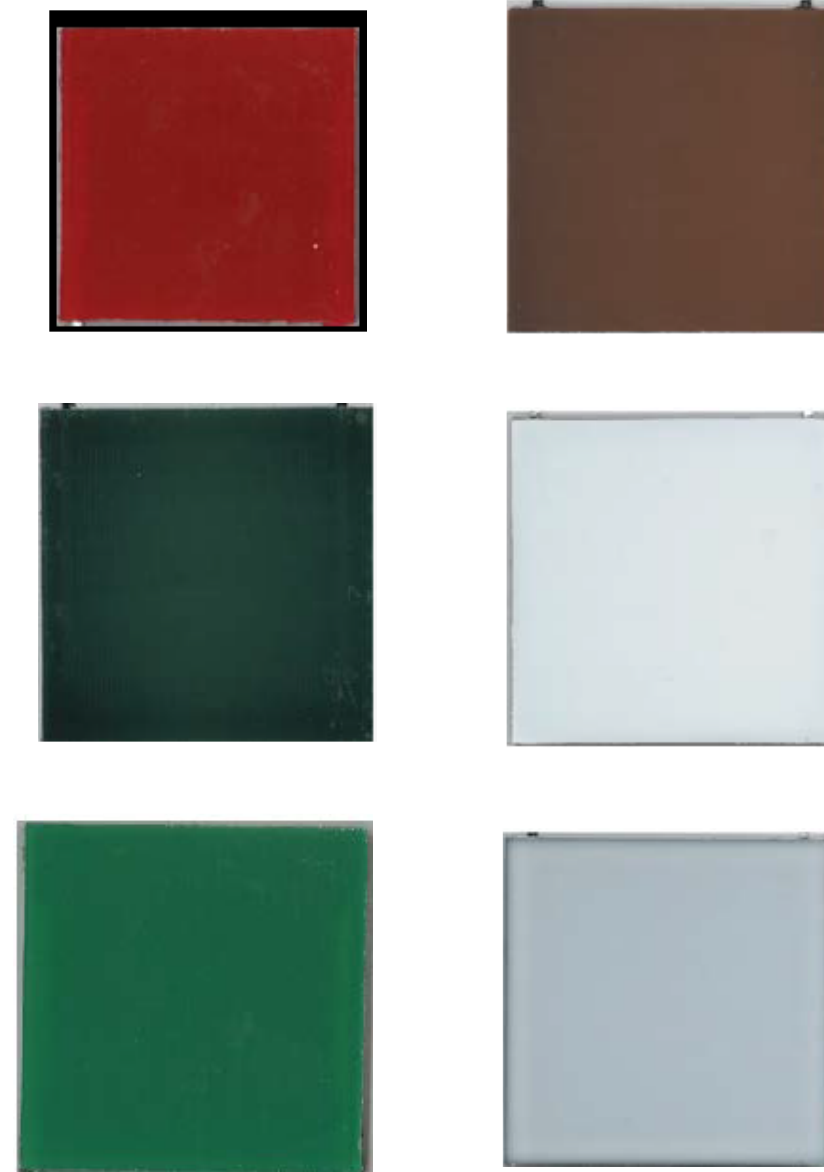
Coloured Solaxess filtre

PICTUREit Solar - Colored Enamelled Front Glass for Colored PV Glazing
184 balanced color for custom design and photovoltaic efficiency

Example of FRONT GLASS Diamant 4mm
Face 1 Flat glass
Face 2 RAL 8004 target
Copper brown
Terracotta

| Order name | Color name | Color code | Color description |
|------------|-----------------|------------|-------------------|
| 1 | Green beige | 1000 | 1000 |
| 2 | Beige | 1001 | 1001 |
| 3 | Sand yellow | 1002 | 1002 |
| 4 | Signal yellow | 1003 | 1003 |
| 5 | Honey yellow | 1004 | 1004 |
| 6 | Black yellow | 1005 | 1005 |
| 7 | Daffodil yellow | 1006 | 1006 |
| 8 | Beige beige | 1007 | 1007 |
| 9 | Lemon yellow | 1008 | 1008 |
| 10 | Oyster white | 1009 | 1009 |
| 11 | Ivory | 1010 | 1010 |
| 12 | Light ivory | 1011 | 1011 |
| 13 | Sulfur yellow | 1012 | 1012 |
| 14 | Sulfur yellow | 1013 | 1013 |
| 151 | Green brown | 8000 | 8000 |
| 152 | Olive brown | 8001 | 8001 |
| 153 | Signal brown | 8002 | 8002 |
| 154 | Clay brown | 8003 | 8003 |
| 155 | Copper brown | 8004 | 8004 |
| 156 | Fawn brown | 8007 | 8007 |
| 157 | Olive brown | 8008 | 8008 |
| 158 | Nut brown | 8011 | 8011 |
| 159 | Red brown | 8012 | 8012 |
| 160 | Teak brown | 8014 | 8014 |

FRONT GLASS TYPE:
 - Clear, Extra-Clear Float : PLANICLEAR, DIAMANT, PARSOL
 - Satinated Glass Clear, Extra-Clear, coloured glasses
 - Patterned Glass : ALBARINO, DECORGLASS (VISIO SUN)
 - Enamelled Glass : PICTUREit Solar, SERALIT Solar
 - Glass of projects delivered by Saint-Gobain Factories to PV Makers
 - From PICTUREit sites : AURYIS, LALIN, ANNECY
 - SOG MANNHEIM, SO SOLAR, WILLSORF, OEGENDORF



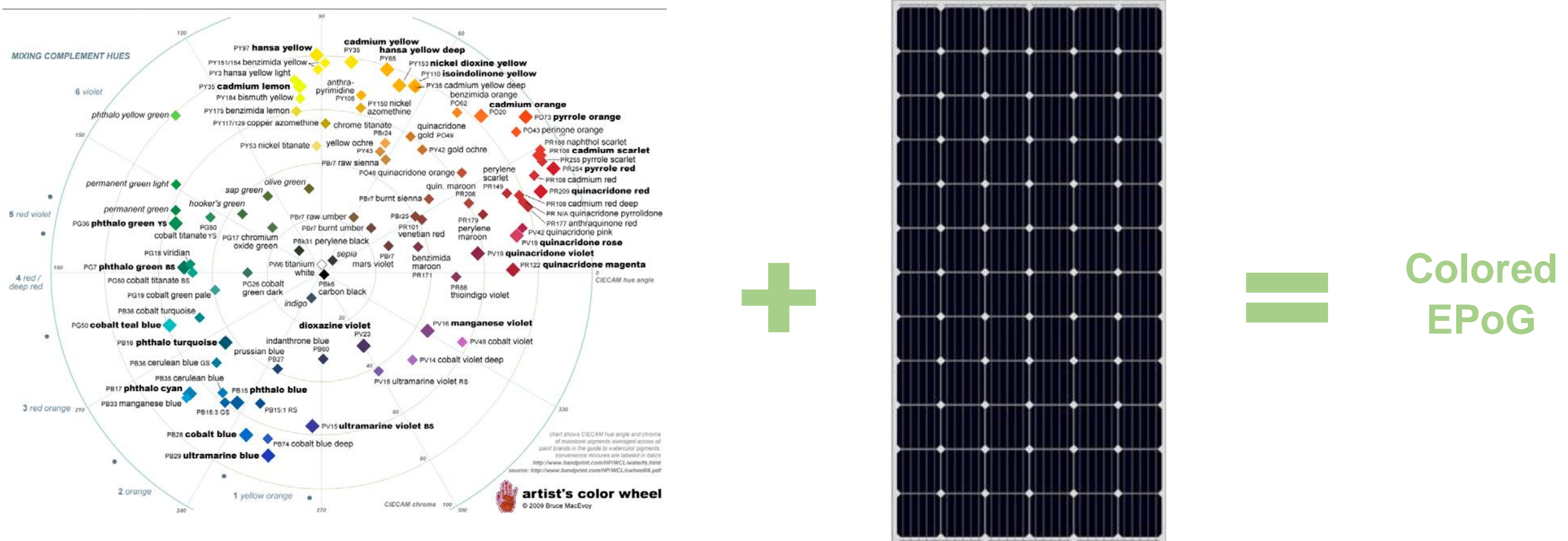
- All 3 techniques are commercially available;
- Portfolio of different colours in expansion;
- Colour matching to a customized colour is a challenge



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Software for colour matching of EPoG elements



- Multiple Actual colour of EPoG: colouring element imposed onto the colours of standard c-Si modules
- Challenge to match a customised colour using traditional software



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Software for colour matching of EPoG elements

Select a pigment mixture and the thickness of the colored layer → Optical model based on 4 flux theory and Mie scattering. Pigments are defined by its refractive index data (n,k) and their size distribution.

Reflectance curve for the reference color selected and the calculated color layer

Comparison of the EQE of a module without colored layer (Ref) and the expected EQE of the module with the calculated color layer.

Possibility to load reflectance curves measured for different reference colors

Possibility to load experimental data for comparing with calculated data

Lab color coordinates for the reference, calculated color layers and experimental data. Display of an RGB color approximation.

Short circuit current of the reference module and the estimated value for the calculated color modules.

Table summarizing color differences (ΔE) and performance differences (ΔJ_{sc}) between color reference, calculated color modules and measured color modules.

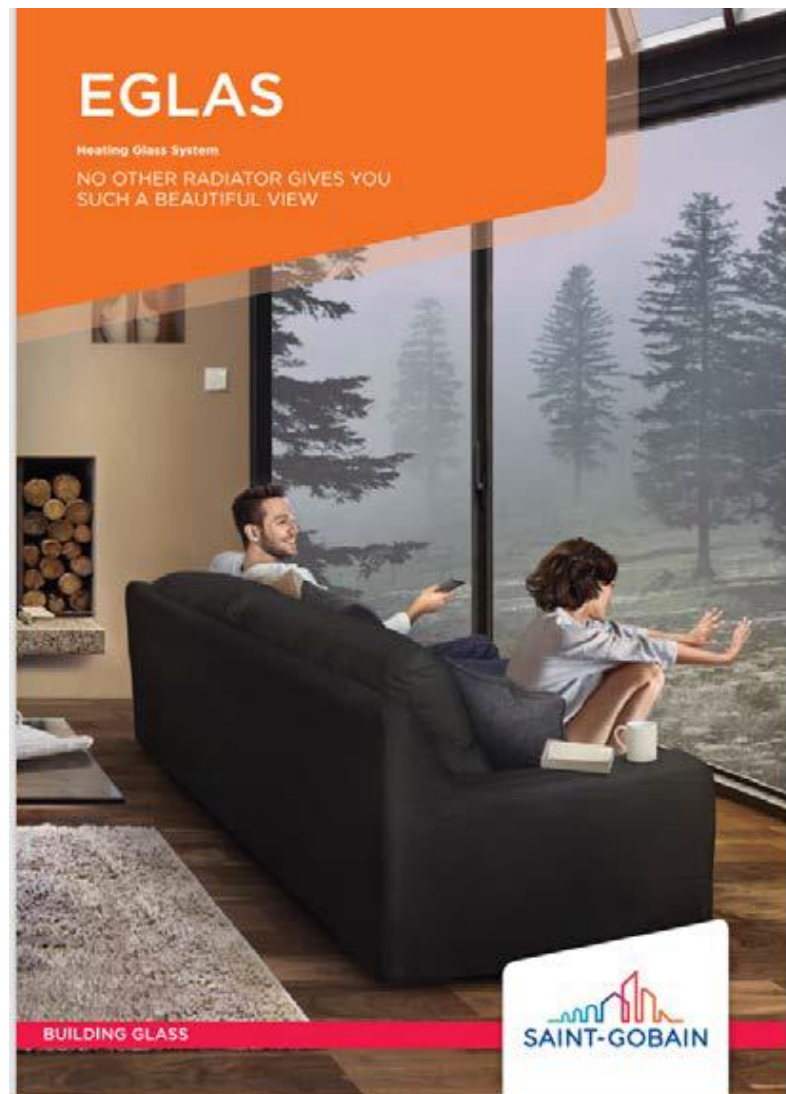
Table summarizing the mixture and thickness used in the calculated color layers and for the experimental modules.

- Software specially developed for coloured EPoG: based on 4 flux theory and Mie scattering;
- Expanding pigment database;
- Recipe proposal for the targeted colour;
- Prediction of module power loss after colouring





Multi-functionality of EPoG elements



TIMELESS-anti-corrosion glass

- EPoG element: an integrated part of building skin
- Top functions of building facade: water ingress; control of air permeability; Resistance of wind load; Thermal/acoustic insulation; solar gain; Aesthetics.
- In Be-smart: self-heating, self-cleaning, anti-corrosion



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**Thank you
for your attention.**