Integrating end-of-life circularity savings into life cycle GHG emissions assessment is critical.

Position paper - 18 June 2024

Today, the debate on whole carbon life cycle impacts in the building sector tends to be restricted to the embodied carbon related to initial production, the operational carbon and the end-of-life impacts without considering the additional environmental benefits resulting from products and buildings designed for reuse or recycling. It also neglects the high durability of some products, which can last much longer than the reference service life of a building.

After a positive vote in March 2024, the [recast Energy Performance of Buildings Directive (EPBD)] was published in the Official Journal on 8 May. By 2028, this new regulation will require the calculation and the disclosure of the whole life carbon assessment for new buildings with more than 1000 m^{2}, while it will be applied to all buildings by 2030.

METALS FOR BUILDINGS members believe that durability and end-of-life circularity benefits should be integrated into the EPBD whole life carbon assessment method to secure consistency and convergence between circularity and decarbonisation objectives. It is essential to acknowledge design-for-reuse and design-for-recycling by integrating complementary end-of-life GHG savings into the life-cycle carbon assessment, as illustrated in Fig.1 below and explained in the following video.

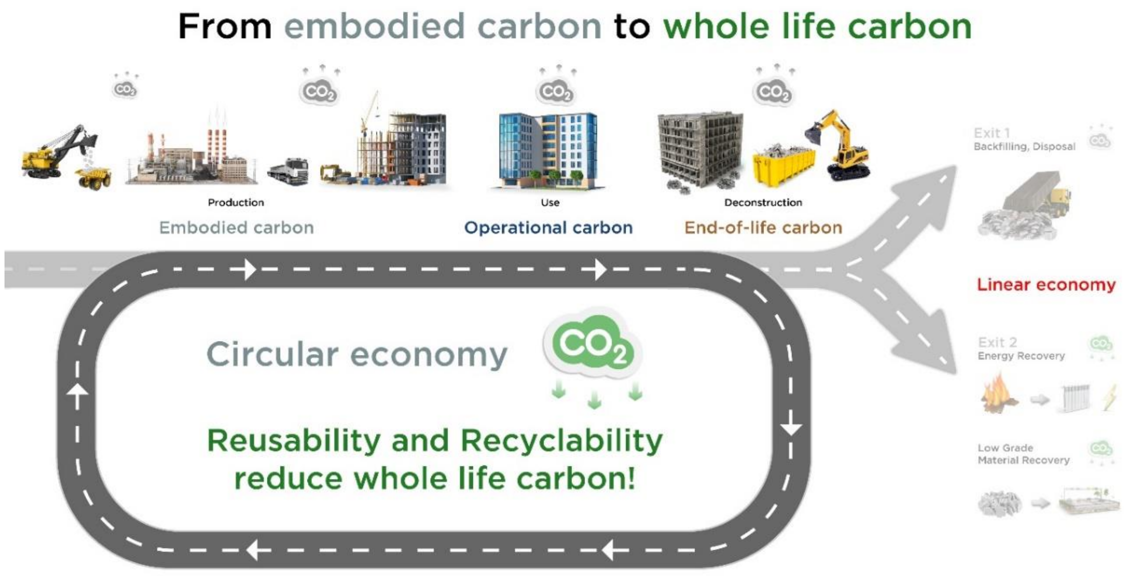

Fig. 1: Reusability & recyclability reduce whole Life Cycle GHG emissions

Therefore, the complementary carbon savings resulting from reuse and recycling at end-of-life stage should be considered in the EPBD life-cycle GHG emissions calculation. These net carbon savings are calculated through the so-called Module D of EN15978[1] (Building-level). Those carbon savings reported in Module D complement the circularity benefits, which are

[1] EN 15978:2011- Sustainability of construction works - Assessment of environmental performance of buildings - Calculation method

only partly considered in the production phase through the recycled content fraction. Special precautions are included in those standards to avoid any double counting/crediting of recycled content during production and recycling rate at end-of-life.

Hence, for the life cycle GHG emissions calculation, METALS FOR BUILDINGS recommends:

- **Reporting the end-of-life complementary carbon savings, which are calculated in the so-called Module D defined in EN15978.**
- **In the case of aggregation of Modules A to D of EN15978, consider applying a factor of 80% to Module D to maximise consistency with the Circular Footprint Formula used in the PEF methodology.**
- **Taking inspiration from the French regulation RE2020, which aggregates Modules A to D, using a specific allocation factor on Modules C & D, which is defined through a dynamic LCA approach.**

“Design for reuse & recycling” is the major pillar of circularity in the building sector.

In parallel to the decarbonisation urgency, there is equally an urgent need to move towards a more circular construction sector. The construction sector accounts for about 40% of all waste generated in the EU, and this will not change unless the engineers or architects fully consider recyclability from the early stage of the building design.

Restricting building circularity to the production phase only is not sufficient. For example, a construction product that has a high recycled content thanks to recycled materials coming from other sectors (e.g. packaging) cannot be considered a circular construction product, and even less if it is downcycled or going to landfilling at the end of the building's life.

Hence, the priority action to increase the circularity of the construction sector is to boost the “Design for reuse & recycling” concept, which integrates the end-of life stage into the design of buildings and infrastructure projects, ensuring that most products and components can be easily dismantled for reuse or recycling, and that all materials flow generated can be economically recycled without downgrading, ideally within the same sector.

In this respect, a recent JRC study[2] emphasises that metals are systematically reused or recycled at the end-of-life of buildings, providing significant environmental and economic benefits. For other materials, the study shows that recycling and reuse also present environmental benefits, but to a lesser extent. However, the lack of profitability is often a barrier to wider recycling or reuse practices for most of those non-metallic materials. Hence, this report demonstrates the importance of integrating “design for circularity” concept in buildings in order to secure that all the materials and products at end-of-life are effectively environmentally and economically reused or recycled.

The construction sector accounts for about 40% of all waste generated in the EU, and this will not change unless the engineers or architects fully consider “design for re-use & recycling” concepts in their projects. We should indeed avoid that the building of today becomes the waste of tomorrow.

[2] JRC study 135470: “Techno-economic and environmental assessment of construction and demolition waste management in the European Union”, January 2024

Module D considers the quantity and quality of secondary materials/products which are generated by the product life cycle.

Construction products and materials can be recycled or reused in different ways and with different levels of circular value retention, in terms of preserving their utility and inherent properties. A material that is poorly valorised at end-of-life and ends up as backfilling material cannot be considered circular material. On the other hand, metals are typical materials with permanent properties that are preserved or restored through recycling. A circular economy aims to keep as much material in closed product or material loops, whilst minimising any loss of inherent material functionality or quality. Hence, it is important to consider the quality of those secondary materials/products as reflected by their true ability to substitute primary materials/products.

The calculation principle defined in Module D reflects such environmental benefits: high quality reused or recycled materials fully substituting primary material will get higher GHG savings than low quality recycled materials poorly substituting primary materials.

While reuse should be intensified, recycling is the main processing route for metal scrap from buildings

Today, end-of-life collection rates above 90% are observed for metal building products, as reported in the JRC study. The fraction of these collected metal products going for reuse is relatively limited in spite of their durability, which preserves their initial properties throughout the building's life. In fact, reuse is mostly restricted by safety or performance regulations, logistics, technological progress or market organisation. Typical metal products reused are columns, beams or cladding materials. The end-of-life reuse rate of those specific components usually does not exceed 10%.

While the reuse option should be intensified in the future, the recycling route stays today the major option for metal products.

Module D is important for metals due to limited scrap availability.

While collection rates above 90% are effectively observed at end-of-life, as reported in the JRC study, the overall fraction of metal products issued today from recycling is significantly lower, e.g. 40%-50% on average. This discrepancy is largely due to the market growth and the long lifespan of metal building products, which limit the quantity of metal scrap available for recycling today. This means that, for metals, reusability and recyclability aspects are only partly reflected at the production stage and should be complemented from a whole life cycle perspective through the additional benefits at the end-of-life stage. Hence, for metal products, there is usually a discrepancy between discrepancy between the Recycled Content percentage (%RC) and the End-of-Life recycling rate (%EoL). In most cases, a metal building product is a net producer of metal scrap over its whole life cycle.

In the example reported in Fig. 2 of the annex at the end of this paper, 1 kg of metal sheet produced from 40% of recycled metal which is recycled at 90% at end-of-life will generate 0,9kg of recycled metal at the end-of-life stage. Since 0,4kg has been used at the production stage, the net production of recycled metal from the product life cycle will be 0,5 kg. Module D will calculate the environmental benefits based on this net production of recycled metal.

In general, metal building products generate more recycled metal at end-of-life than they use at the production stage. Hence, it is important to address this discrepancy and the additional benefits resulting from this net scrap generation. Module D typically calculates the complementary environmental benefits resulting from this net flow of recycled metal generated from the product life cycle.

Consistency with the Product Environmental Footprint (PEF) methodology is critical.

- What about metals?

For other markets, the new EU environmental legislations which will soon enter into force, like the battery regulation or the Ecodesign for Sustainable Products Regulation (ESPR), refer to the Product Environmental Footprint (PEF) methodology. A recent JRC report published in March 2024 related to the "Review of the MEErP :Methodology for ecodesign of energy-related products" has confirmed the alignment of this methodology to PEF._ In particular, for the calculation of the whole life carbon footprint, the so-called Circular Footprint Formula (CFF) is used. This formula uses an *allocation factor A,* which is material-dependent. For metals, this factor is equal to 0,2, meaning that for the whole life cycle carbon calculation, 20% of the %RC is considered, as well as 80% of the end-of-life recycling rate. For a metal sheet made of 40% recycled metal at the production stage, which is recycled at 90% at the end-of-life stage, this means that the CFF will consider a contribution of 0,2 * 40% = 8% of recycling at the production stage and a recycling benefit at the end-of-life stage of 0,8 * 90% = 72%. In other words, the whole Carbon Footprint of this metal sheet will be calculated on the basis of 80% from metal recycling (8% +72%) and 20% from primary metal.

Using the same metal sheet example with the methodology developed in EN15804 or in EN15978, the whole Carbon Footprint will be calculated either on the basis of 40% metal recycling in case of exclusion of Module D or on the basis of 90% metal recycling in case of inclusion of Module D. This second option including Module D is definitely closer to the CFF calculation results[3]. By simplifying the CFF equation, it can be shown that both calculations can be aligned provided that a factor equal to (1-*A*) is applied to Module D as reported below:

CFF = "Module A" + (1-*A*) x "Module D"

For metals, the allocation factor is equal to 0,2. Hence, the equation is then the following:

CFF = "Module A" + *0,8* x "Module D"

This consistency between the PEF methodology and the EPBD WLC method is particularly important since several building equipments, e.g. heating systems or PV panels, will be governed by the ESPR and the associated PEF methodology. It won't be meaningful that the same metal sheet leads to two very different whole carbon footprint results depending on whether it is part of a heat pump or a photovoltaic system, which are calculated with the CFF or a building cladding element which is calculated on the basis of EN15978.

In the same spirit, it is not recommended that the identification of low-carbon products depend on the methodology. For example, for the same function, the WLC assessment, excluding Module D, may identify a poorly recyclable glass-fibre reinforced non-metallic sheet as the best environmental option, while the PEF method may identify a recyclable metal sheet as the best environmental option.

[3] Simplified calculation examples are given in Annex 1 at the end of this position paper

- What about other materials?

The allocation factor used in the CFF is material-dependent and is based on the level of demand for secondary materials by the market. Reused/recycled metals are in high demand thanks to their high quality and ability to substitute primary metals. An allocation factor of 0,2 is used for them. For other materials, a higher value for A is used due to a lower demand for secondary materials, e.g. the factor is usually 0,5 for plastics and 0,8 for textiles. It can be argued that the use of A = 0,2 will generate diverging results for the other materials. However, this divergence will not be significant for the following reasons:

- For other materials, the GHG results reported in module D are usually small compared to other modules due to the limited environmental savings resulting from reuse or recycling.
- Should those GHG savings be important, it shows that the quality and the value of the reused/recycled material are high. As a result, the demand for those reused/recycled materials will be high and will justify an adaptation of the allocation factor used in the CFF formula.

In other words, by applying the concept of "design for deconstruction", the quality of the secondary materials will increase. The demand should move in the same direction, justifying then the allocation factor A of 0,2 to be applied for demanded secondary materials. Hence, ultimately, the use of A = 0,2 for all materials should drive the concept of "design for deconstruction" and secure a convergence of both methodologies in the medium or long term for all materials

As a result, the consideration of Module D in the WLC assessment will secure a much better consistency with the Product Environmental Footprint (PEF) methodology. To maximise consistency with the Circular Footprint Formula (CFF), a factor equal to 80% should be ideally applied to Module D in case of aggregation of Modules A to D.

The French regulation RE 2020 as a source of inspiration

After several years of testing and adaptations, the RE2020 regulation has been applied since 2020 in France to new buildings. This regulation defines maximum thresholds for the operational energy demand and for the overall life cycle carbon of new buildings. This methodology is based on the building standard EN15978. For the whole life carbon calculation, the French methodology uses a so-called dynamic LCA, which aggregates all modules of this standard, but an attenuation factor is applied for the two Modules C and D. This attenuation factor depends on the building service life, which is considered. For a typical service life of 50 years, this dynamic factor is 57%, while it is 75,6% for a service life of 30 years. Such a dynamic LCA approach allows us to consider the environmental impacts or savings in accordance with the elapsed time they will occur, based on the used reference scenario.

Those dynamic factors are quite close to the CFF methodology, which corresponds to a factor of 80% for metals.

Hence, inspiration should be taken from this French RE 2020 regulation in order to promote convergence with the PEF method.

European metals alliance for recyclable & sustainable buildings

About METALS FOR BUILDINGS:

Founded in 2011, METALS FOR BUILDINGS is an *alliance of European or International metal trade associations* active in the building sector. It represents the interests of the metal industry towards European institutions and relevant stakeholders as far as the sustainability and recyclability credentials of metals in buildings are concerned.

METALS FOR BUILDINGS is directly active in CEN/TC 350 - Sustainability of construction works and monitors various relevant LCA methodology and framework developments like the Product Environmental Footprint (PEF) methodology or the Level(s) framework.

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Annex 1 – examples of GHG calculations based on EN15978 and on PEF-CFF.

This simplified example, illustrated in Fig. 2, only reports the calculation principle for the metal production and recycling, i.e. ingot production but it does not consider all the downstream manufacturing processes. This example assumes the production of 1 kg of a metal sheet made of 40% recycled metal (i.e. 0,4 kg of scrap input to Module A), which is recycled at a rate of 90% at end-of-life (i.e. 0,9 kg of scrap output from Module C).

Module D reports the additional benefits resulting from the net flow of scrap leaving the system, representing 50% of recycled metal, i.e. 0,5 kg of scrap, which is not addressed by the recycled content[4]. These benefits are calculated by substitution, considering the environmental burdens of recycling/reuse for 0,5 kg of metal balanced by the savings of the environmental burdens of the primary metal which is substituted, and which are potentially attenuated by a quality factor reflecting the level of preservation of the material/metal properties.

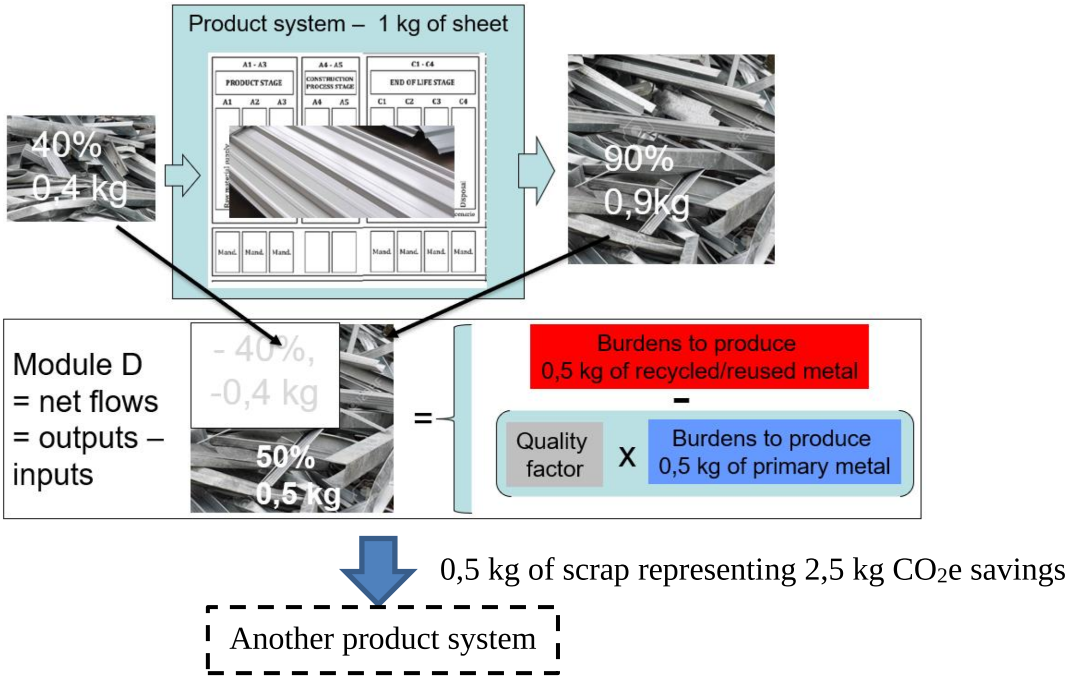


Fig.2. Module D calculation principle as per EN 15804 & EN15978

1) Calculation example based on EN15978

Example of calculation for the GHG emissions using the above fictive example of 1 kg of metal sheet
Hypotheses:

- Impact of primary ingot production: 6 kg of CO_2e/kg ingot
- Impact of recycled ingot production: 1 kg of CO_2e/kg ingot
- Quality factor = 100%, i.e. no alteration of the properties through recycling

Results
Module A1 (production) calculation for 1 kg of metal sheet (excluding the conversion of the ingot into sheet and the metal losses)

- 40% of recycled content shall be used
- **Module A**: 0,4 * 1 kg CO_{2e} + 0,6 * 6 kg CO_{2e}= **4 kg CO_{2e}**

[4] For simplicity reasons, such mass flow neglects the metal losses during the melting/recycling process

Module D calculation (neglecting metal yield/losses of the recycling processes)

- A **net** flow of 0,5 kg of metal scrap enters Module D. Hence this flow shall be used to calculate Module D

Module D = 0,5 kg * [1 kg CO_{2e} – 100% * 6kg CO_{2e}]
= 0,5 kg * [- 5 kg CO_{2e}] = **- 2,5 kg CO_{2e}**

In such a case, 0,5 kg of metal scrap conveys a carbon saving of +2,5 kg CO_2e leaving the system, providing then an environmental benefit of -2,5 kg CO_2e.

2) Calculation based on Circular Footprint Formula (CFF)

The CFF for the material fraction is as follows:

Material

$$(1-R_1)\times E_V + R_1\times(A\times E_{recycled} + (1-A)\times E_V\times Q_{Sin}/Q_p) + (1-A)\times R_2\times(E_{recyclingEoL} - E_V^*\times Q_{Sout}/Q_P)$$

Hypotheses:

Using the above CO2 figures for the process emissions, we have

- $E_v = E_{v*}$ = 6 kg CO_{2e}/kg ingot
- $E_{recycled} = E_{RecyclingEoL}$ = 1 kg CO_{2e}/kg ingot

Additionally, for metals, we have

- the *allocation factor A* = 0,2
- $Q_{sin}/Q_p = Q_{sout}/Q_p$ = 1 (quality preserved through recycling)

Results

CFF results = (1-0,4)*6 + 0,4*(0,2*1+(1-0,8)*6*1)+(1-0,2)*0,9*(1-6*1)

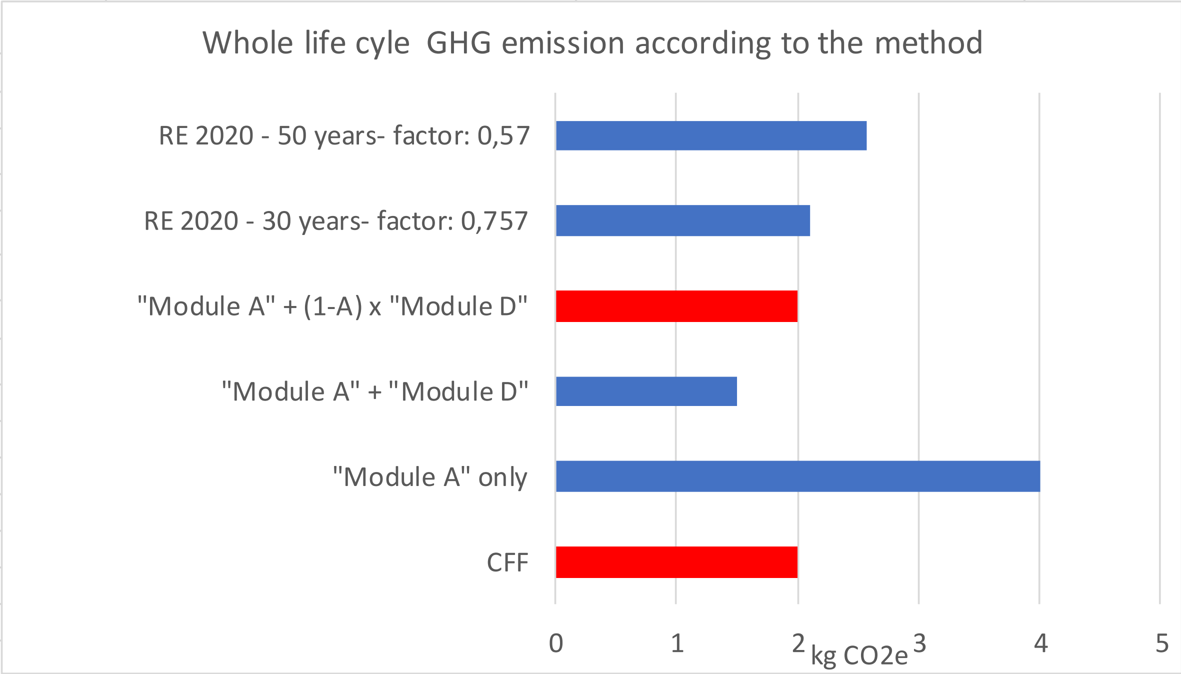
CFF = 5,6 – 3,6 = 2 kg CO_{2e}

3) Alignment of EN15978-based calculation to CFF

How to align the WLC GHG emission calculation to the PEF -CFF formula

CFF equation:	Material $(1-R_1)\times E_V + R_1\times(A\times E_{recycled} + (1-A)\times E_V\times Q_{Sin}/Q_p) + (1-A)\times R_2\times(E_{recyclingEoL} - E_V^*\times Q_{Sout}/Q_P)$	
Hypothesis for simplification:	$E_v = E_{v*}$	Primary production burdens = primary burdens substituted at EoL
	$E_{recycled} = E_{recyclingEoL}$	Recycling burdens at produciton stage = recycling burdens at EoL
	$Q_{sin}/Q_p = Q_{sout}/Q_p = 1$	Quality of recycled materials are equal to primary materials
Simplified CFF equation	$(1-R_1)xE_v + R_1x[A\ x\ E_{recycled} + (1-A)xE_v] + (1-A)xR_2x(E_{recycled}-E_v)$	
Simplified CFF equation -Step 1	$(1-R_1)xE_v + R_1x[E_{recycled} - (1-A)xE_{recycled} + (1-A)xE_v] + (1-A)xR_2x(E_{recycled}-E_v)$	
Simplified CFF equation -Step 2	$(1-R_1)xE_v + R_1xE_{recycled} - (1-A)xR_1x(E_{recycled}-E_v) + (1-A)xR_2x(E_{recycled}-E_v)$	
Simplified CFF equation -Step 3	$(1-R_1)xE_v + R_1xE_{recycled}$ + (1-A) x $(R_2-R_1)x(E_{recycled}-E_v)$	
	"Module A" + (1-A) x "Module D"	
Simplified CFF equation :	**"Module A" + (1-*A*) x "Module D"**	
	A = Allocation factor = 0,2 for metals	
Simplified CFF equation for metals :	**"Module A"+ 0,8 x "Module D"**	

Results		$kg\ CO_{2e}$	% diff vs. PEF
PEF	CFF	2	/
Based on EN15978	"Module A" only	4	100%
	"Module A" + "Module D"	1,5	-25%
	"Module A" + (1-*A*) x "Module D"	2	0%
	RE 2020 - 30 years- factor: 0,757	2,1075	5%
	RE 2020 - 50 years- factor: 0,57	2,575	29%



The CFF calculation gives 2 kg GHG emissions, while the WLC calculation excluding Module D gives 4 kg GHG, showing a divergence of 100%. The inclusion of Module D with a factor of 80% ensures a full alignment to the CFF, while the French regulation RE2020, with its partial consideration of 75,7% or 57% significantly reduces this divergence