SCORE LCA

STUDY No. 2022-01

LOCATION-BASED ELECTRICITY MIXES VERSUS MARKET-BASED ELECTRICITY MIXES: WHAT RECOMMENDATIONS FOR LCA?

Synthesis

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SCORE LCA is an association that has been created to financially support collaborative research on LCA and related topics. It aims to promote and organize cooperation between companies, institutional and scientists in order to support the evolution of LCA methods and its practical implementation at European and international level.

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- The views and recommendations expressed in this publication are those of the authors and do not necessarily reflect, unless otherwise stated, the views of all members of SCORE LCA.

  The information and conclusions presented in this document were established on the basis of scientific and technical data and regulatory and normative framework in force at the date of the publication of documents

A. WHY PERFORM A STUDY ON THE APPROACH TO MODELLING ELECTRICITY ACCORDING TO ATTRIBUTIONAL LCA?

Following a period when so-called geographic (Location-based) mixes were those most used in LCA to model electricity consumption delivered by the grids, an increasing number of methodological frameworks require as first choice the use of contractual information specific to each electricity consumer.

To attest the mode of electricity production, the contractual characteristics demanded are attached to Energy Attributes Certificats (EAC): Guarantees of Origin (GO) in Europe, and other types of certificates in the rest of the world (e.g., RECS, i-REC, REGO). According to the contractual instruments used, these certificates may or may not be correlated to the physical flows of the electricity consumed.

In the context of attributional LCAs, the members of SCORELCA wanted to understand different aspects:

- What are the methodological rules established by the reference frameworks currently used in environmental assessments related to modelling electric mixes?
- What are the principles for building the different types of electric mixes in the generic databases used in LCA?
- Recourse to contractual instruments to model the electricity delivered by grids gives rise to serious debates between the stakeholders; what are the positions of the actors?
- What are the practical and methodological challenges of implementation? What recommendations can be formulated? For example:
    - Is the final aim of LCA works likely to influence methodological choices?
    - How is it possible to show that one conforms to the general requirements of consistency of approach as set out in standard ISO 14044?
    - What access to the residual mixes in the databases used in LCA at present?

To carry out this study, the work plan presented in the following figure was followed.


-1-
Regulatory and bibliographic analysis
Establishment of an inventory of the main French and European regulations governing contractual electricity instruments.
Description of the mechanisms of issue, utilisation and transfer of Guarantees of Origin (GO).
Map of primary energy sources considered as RENs,
Synthetic analysis of the GO market in Europe: annual quantity issued, quantity of transactions, main sources of renewable energy concerned, main exporting/importing countries.
Definition and illustration of the concept of Residual mix in a Market-based approach.
Analysis of the contributions of certain voluntary labels (the VertVolt label of ADEME)
Identification of the different types of contractual instruments enabling claims of electricity produced from renewable energy sources.
STUDY REPORT SECTION B
-2-
Methodological analysis
Analysis of methodological choices relating to electricity defined in twenty methodological frameworks for lifecycle analyses (LCA) oriented for products and organisations: PEF/OEF, GHG Protocol, Int. EPD® System, SBTi Corporate Manual, Net Zero Initiative, etc.
Establishment of a synthesis of ranking electricity profiles according to the reference frameworks examined.
Analysis of eligibility criteria of contractual instruments according to the reference frameworks.
Production of a state of the art of academic works relating to the implementation of the Market-based approach to LCA.
Production of a case study aimed at identifying the constraints of implementing the Market-based approach, the consequences in terms of results and aiding decision between the Location-based and Market-based approaches and the challenges of consistency of the approach. Paths of reflection are proposed to improve the Market-based approach considering the data available in current databases.
STUDY REPORT SECTION C
-3-
Analysis of actor's positions
Reproduction of the main results of the survey carried out in the framework of revising GHG Protocol Scope 2.
Identification of arguments for and against the Market-based approach.
Synthesis of proposals of certain actors in view to improving the Market-based approach.
STUDY REPORT SECTION D
-4-
Inventory of LCA databases
Establishment of a recall of the concept of Location-based electricity mix and analysis of academic works on this subject.
Production of a descriptive analysis of the methodological choices chosen in the ecoinvent database regarding the Market-based and Location-based electricity inventories.
Comparison of the environmental impacts of different kWh between the Market-based and Location-based approaches and analysis of transfers of impacts.
STUDY REPORT SECTION E
-5-
Recommendations for applying the market-based approach
Establishment of recommendations adapted according to the goals and contexts of using LCA works: aid for innovation, improvement, comparison of solutions and communication.
Proposal of choices and ranking electricity mixes for the steps under control or not of the entity performing the LCA study.
Methodological proposal aimed at improving the consistency of the approach within the entity performing the LCA study.
Establishment of recommendations on the implementation of contractual instruments and on the construction of contractual mix lifecycle inventories with REN attributes: eligibility of instruments, types of proof, duration of validity, methodological choices for losses on line linked to transport and distribution, taking into account renewable electricity production infrastructures, etc.
Proposal of a check-list for implementing the Market-based approach for LCA analysts responsible for performing or conducting a critical review of LCA studies.
STUDY REPORT SECTION F and annex

B. INTRODUCTION TO KEY CONCEPTS

B.1 MARKET-BASED APPROACH/ LOCATION-BASED APPROACH: WHAT ARE WE SPEAKING ABOUT?

The geographic or location-based approach considers the environmental impacts linked to electricity use as a function of the geographic area in which it is consumed. The same average profile per kWh will be applied to all the electricity consumers of the grid; no differentiation between the electricity suppliers of the same grid or between the electricity offers (electricity products) of the same supplier needs to be considered.

As this approach does not take account of the possible existence of contractual instruments, this average profile will therefore include sources of electricity production connected to this grid for which certificates (Guarantees of origin or other) have been issued, then sold in a specific way to certain consumers.

The market-based approach aims at reflecting the electricity profile that consumers have deliberately chosen (or not chosen). It is therefore based on taking account of contractual instruments. This approach is based on the fact of holding or not EAC certificates (guarantees of origin, etc.) bearing the declaration of renewable electricity origin, for example, it being specified that these flows of contractual information can be decorrelated from underlying energy flows in the grid (bundled or unbundled certificates).

In the case where the electricity consumed does not possess attributes (e.g., GO), the market-based approach therefore implies a mix of residual electricity. The residual mix is the mix of energy sources that remain once the consumption tracked (with EAC/GO) is withdrawn from the mix.

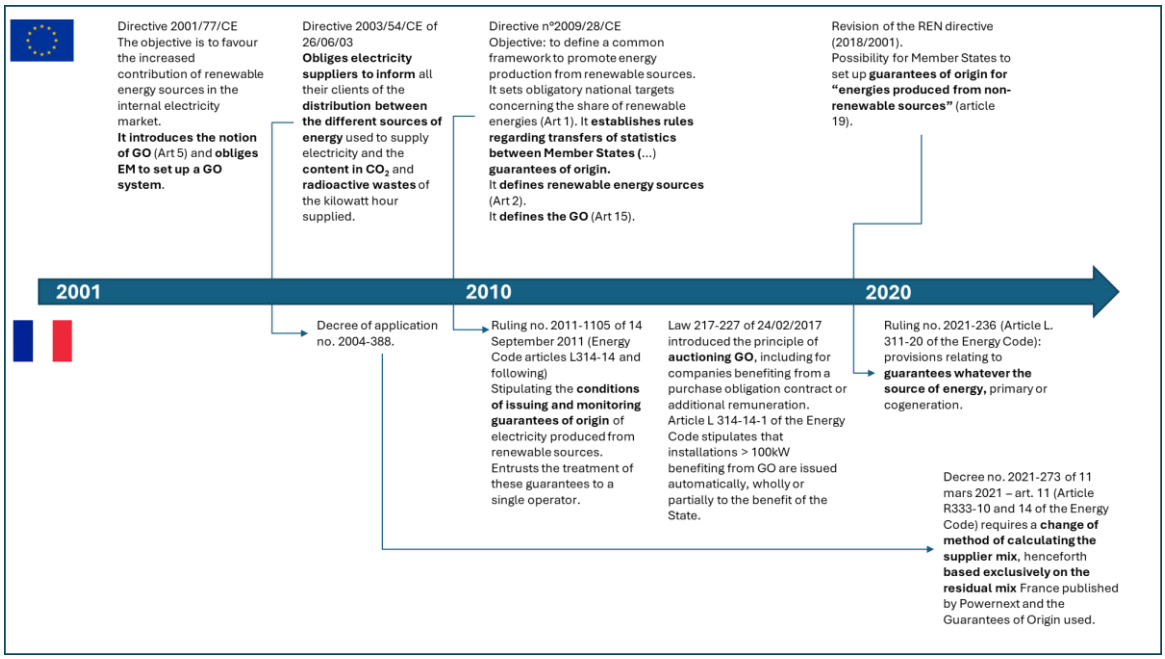
B.2 MARKET-BASED APPROACH: GUARANTEES OF ORIGIN

At the origin of the market-based approach, regulations

In Europe, contractual electricity instruments have been integrated in law since the directive on renewable energies of 2001. This demands from Member States that the origin of the electricity produced from renewable energy sources can be guaranteed.

The revision of the directive on renewable energies in 2009 strengthened the provisions by introducing the notion of guarantee of origin (GO), which has become the means of proof that the electricity is produced from a renewable source. In addition, the directive specifies that a guarantee of origin issued in a Member State is valid throughout the European Union.

The following chart presents the main European and French regulatory texts enshrining the principles of GO.



Guarantee of origin: definition

According to the definition given by the Energy Code (Article R311-48): "*A guarantee of origin is an electronic document used solely to prove to the final client that a part or a given quantity determined equivalent of the energy supplied was produced by a given source of primary energy or by cogeneration. Transfers, taken separately or in connection with the physical transfer of energy, and cancellations of guarantees of origin are not taken into account in the calculation of the share of energy produced in France from renewable sources in the final gross national consumption, and cannot be used to reach the objectives set by sub-clause 4 of clause I of article L. 100-4.*"

A guarantee of origin is delivered to the producer who asks for it for each MWh produced from renewable energies or from cogeneration, and injected into the transport and distribution grid.

FOCUS: information associated with a GO

For each guarantee of origin, the information of the register accessible to the public is (Article R314-64 of the Energy Code):

1° the identification number of the guarantee of origin and its country of issue;

2° the date of its issue or of its importation;

3° the name and capacity of the requesting party;

4° the name and place of installation of electricity production and its power;

5° the source of energy from which the electricity was produced;

6° the start and end dates of the period for which the request for guarantees of origin applies;

7° the date on which the installation was commissioned;

8° the type and amount of national aids benefitting the installation […];

9° when applicable, the mention of the record […] and the name of the holder using the guarantee of origin or the mention of exportation of the guarantee of origin.

The life cycle of a guarantee of origin (GO)

Each MWh of REN electricity is attributed a GO when the producer so requests. The term **"issue"** is used. The GO can be coupled to the MWh sold or unbundled, that is to say sold independently of the sale of MWh that was at the origin. In this case, the GO is **"transferred"**.

In Europe, most national organisations responsible for managing guarantees of origin are grouped in the Association of Issuing Bodies (AIB), whose aim is to permit exchanges of guarantees of origin thanks to the European Energy Certificate System - "EECS"). A guarantee issued in a country of the European Economic Area (EEA) can therefore be used in any other country of this area.

The final client purchases the GOs up to the quantity of electricity they use. The GO are then called **"cancelled"** so they can only be used once. If the GOs are not purchased in the year when they were issued, they therefore become **"expired"**.

Nature of energies covered by GOs

Initially, article 2 of Directive no. 2009/28/CE defined energy produced from renewable sources as being produced from renewable non-fossil sources, that is:

- wind power;
- solar power;
- aerothermal power;
- geothermal power;
- hydrothermal power;
- marine power and hydroelectricity;
- biomass;

- landfill gas;
- gas from waste water treatment plants and biogas.

The revision of the REN directive (2018/2001) provided Member States with the possibility to implement guarantees of origin for *"energies produced from non-renewable sources"* (article 19). In France, decree no. 2023-1048 of 16 November 2023 relating to the guarantees of origin of electricity changed the rules of utilisation of guarantees of origin for electricity resulting from all sources of primary energy.

A brief look at the European GO market

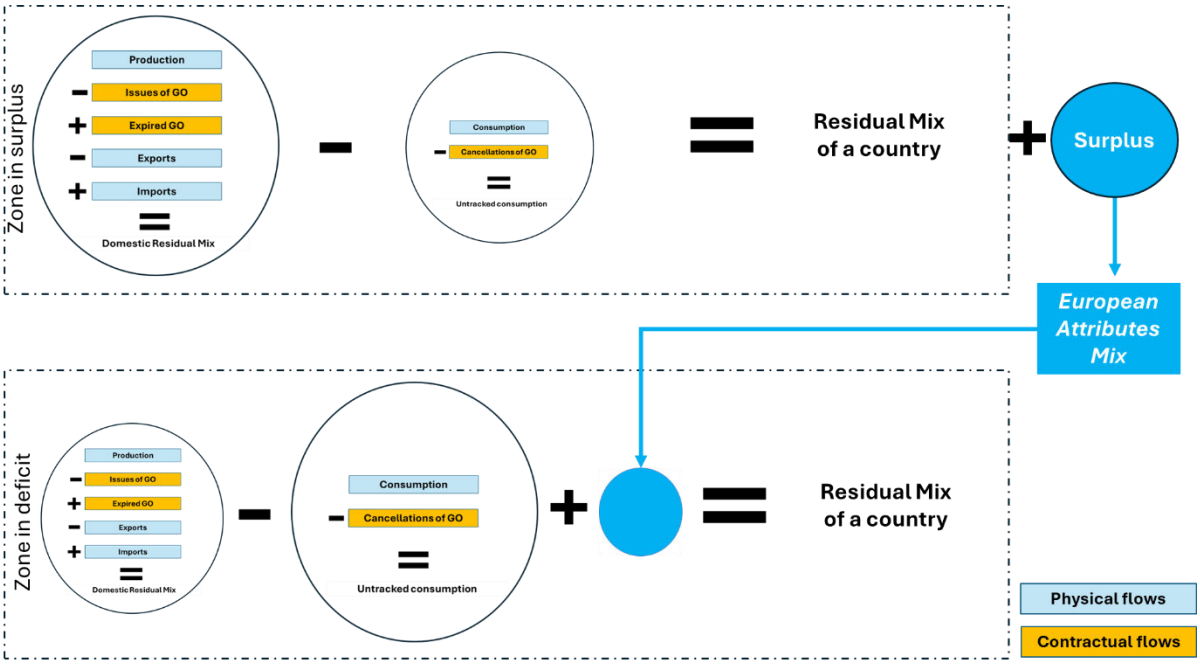
According to AIB, about 850 TWh was subject to issues of GOs in 2021 (AIB, 2021). Hydroelectricity was the main receiver of GOs issued in Europe.

Norway is the leading issuer of guarantees in Europe due to the size of its hydroelectricity sector and to the high rate of GOs imported and exported. Germany appears to import the highest quantity of GOs.

B.3 MARKET-BASED APPROACH: RESIDUAL MIX

In order to establish the "Residual Mix" of a country, the basic principle consists in establishing first a "domestic residual mix" (intermediary calculation) proportional to the net volume of available electricity (production + physical imports – physical exports) and adjusted for the volume of attributes issued and expired for the generated electricity in the country.

If the volume of the domestic residual mix is higher than the untracked consumption in the country (consumption, which has not been disclosed with explicit tracking instruments), the surplus is transferred to a European virtual pool (European Attributes Mix - EAM). Otherwise, the deficit is made up thanks to surpluses available in the EAM, which allows for the establishment of the residual mix of the country. This principle is shown in the following figure.



C. THE POSITIONS OF THE ACTORS AND METHODOLOGICAL FRAMING IN LCA: THE MAIN LESSONS

C.1 MARKET-BASED APPROACH: THE BASIC POSITIONS AND THE DEBATES BETWEEN THE ACTORS

The main arguments "For" and "Against"

MARKET-BASED APPROACH	
For	**Against**
• **Reflects the choice of individual purchases made by companies when electricity is supplied by collective grids.** • **Favours changes of electricity grids (aggregational theory of change).** **But subject to major criticisms and debates** between the actors that favour this method. Schematically, two opposing trends stand out: ❖ Actors that want to strengthen causality criteria in order to better correlate contractual provisions with physical reality and respond to criticisms relating to this method's lack of credibility /precision. ❖ Actors that want maximum flexibility and less constraining criteria.	• **Absence of causal relations between the real impacts and current rules relating to market instruments.** • **The method does not encourage prioritising more significant levers of action for their energy transition**, i.e. their energy efficiency (consume less) and sufficiency (do less). • **Risk of erroneous and even misleading information, notably in the context of science-based targets.** • **Overestimation of the efficiency of mitigation efforts (of climate change) due to transfers of impacts between consumers,** to the detriment of certain categories of consumers not subject to reporting obligations. • **Criticisms of hypotheses underlying "market ideology" and the Aggregational theory of change**

▼ **The arguments "for"**

The actors favourable to the Market-based approach put forward that it:

i) permits **reflecting individual choices of purchase** of companies (contrary to the Location-based approach) and **empowering them**,
ii) favours changes of electricity grids (aggregational theory of change).

Without a market-based approach, companies and organisations would be unable **to exert an influence** on the type of energy purchased, the amount of which they cannot reduce.

▼ **The arguments "against"**

There is no causal relation between the real impacts and the current rules relating to market instruments.

Certain actors, including those who favour the Market-based approach, state that there is an excessive decorrelation between physical reality and certain contractual tools currently used due to over-flexible and non-constraining eligibility criteria. The annual validity of EAC certificates allows declaring as RENs electricity consumptions performed when this type of source is not operational.

Appropriating part of a whole is problematic

Other actors are in basic disagreement with this type of contractual provision that does not reflect the dependency of consumers demanding these provisions regarding all the functions supplied by the electricity grids (grid balancing, backup capacity, etc.). These functions are supported financially by taxpayers and other energy consumers.

No encouragement given to prioritising the most significant levers of action

The consumers that gain an advantage from contractual instruments can declare zero or low greenhouse gas emissions without even having to reduce their real energy consumption. This approach therefore does not encourage prioritising the levers essential for energy transition and the combat against climate change: energy efficiency and sufficiency (do less).

With the annual validity of certificates, this mechanism functions as a free "virtual storage" of REN electricity. This leads to a weak incentive to improve the operation of REN production resources (e.g., storage capacity) and changing the hourly consumption profiles of companies.

Risks of wrong or misleading information in the case of science-based approaches

The purchase of attributes issued for historic REN production resources increases *de facto* the Market-based impacts of the other actors that are not subject to reporting obligations (e.g., households). This means that the total emissions declared according to the market-based approach more than likely overestimate the real reduction of the total emissions of the grid due to incomplete declaration. In the context of science-based goals (e.g., SBT initiative), stating that companies can reach these goals without reducing global emissions would be misleading for the stakeholders.

Subjects in debate

Temporal concordance	
For better correlation with physical reality	**For maximum flexibility**
• Privilege short periods, ideally hourly[1], to match electricity consumption with market instruments and favour levers of action leading to a change in grids.	• Move towards greater detail, e.g., hourly, electricity consumption and contractual tools may not be available to small consumers.

Geographical concordance	
For better correlation with physical reality	**For maximum flexibility**
• Declare clear criteria on the territorial limits for issuing EAC that match the physical localities of consumption. • Limit international exchanges of guarantees of origin to reservations of capacities of physical interconnections between countries.	• Opting for the total decorrelation between the place of consumption and the place of issue of EAC would give access to a wide range of opportunities.

Addition of an additionality criterion	
For	**Against**
• Only taking into account the market tools that respond to additionality criteria would limit the risk that entities declare that they have reached their reduction goals without really having reduced global GHG emissions.	• Over-strict rules will reduce the contractual access of small consumers who are unable to sign long-term contracts with new assets. • The notion is complex, non-consensual, and possibly difficult to prove. • Additionality pertains to consequential reasoning, to be dealt with by separate reporting.

[1] In Europe, an hourly time step is envisaged for 2030 to track guarantees of origin attesting to the origin of renewable hydrogen produced by electrolysis, which is different from the general case for other uses of electricity.

C.2 LOCATION-BASED OR MARKET-BASED APPROACH: HOW ARE THE LCA AND GES REFERENCE FRAMEWORKS POSITIONED?

About twenty recently created or updated reference frameworks have been examined according to a common analysis grid.

	"Product" approach		"Organisation" approach	
Multi-impact quantification	• Product Envir. Footprint	JRC/EC	• Environmental Footprint Organisation (EU)	JRC/EC
	• International EPD® System	EPD Int. AB		
	• EN 15804+A2	CEN		
	• prEN 15941 : 2022	CEN		
	• PEP Ecopassport	PEP Ecopass.		
	• Programme INIES	Alliance HQE-GBC		
"GHG" targeted quantification	• ISO 14067 : 2018	ISO	• GHG Protocol	WBCSD/WRI
	• Product Carbon Footprint - Pathfinder-Framework	WBCSD	• ISO 14064-1	ISO
			• BEGES regulations France	Ministry
	• Product Carbon Footprint - Guideline for the Chemical Industry	TfS (chemical companies)	• ISO IWA 42:2022 - Net Zero Guidelines	ISO
			• SBTi Corporate Manuel	SBTi
			• Net Zero Initiative – Collective Carbon Neutrality	Carbone 4
Targeted climatic and financial risks			• SEC Climate-Related Disclosures for Investors	SEC (US)
			• IFRS S2 Climate-related Disclosures	IFRS

REFERENCE FRAMEWORKS EXAMINED

1| "Location-based" versus "Market-based": what rules?	• Rules applied for **different steps of the lifecycle** or value chain, including:
	  • Steps under the control of the entity
	  • Utilisation phase
	  • Other steps not under the entity's control
	  • Avoided electricity: (i) during the end of life of wastes and/products, (ii) via coproducts (substitution)
	• Coexistence of **different rules** of one step with another for the same reference framework.
	• **Type of rule**: explicit, implicit, absence

2| "Market-based": ranking of mix types	• **Ranking of types of electricity mixes to be used** when it is not possible to claim an electricity product with REN and the nature of these mixes. • **Mesh of representativeness** recommended/expected of residual mixes. • Possibility of **recourse or not to geographic mixes** in certain situations. If yes, which ones?

3| Eligibility criteria of specific contractual instruments	• **Existence and scope of eligibility criteria** of contractual instruments, including:
	  • Nature of environmental attributes
	  • Single ownership of environmental attributes expected
	  • Absence of double claim of attributes
	  • Contractual instruments accepted
	  • Temporal concordance between the electricity consumed and the contractual claim.
	  • Spatial concordance between the electricity consumed and the contractual claim.
	• Other criteria that are potentially pertinent but absent from the refence frameworks.

4| Modelling of specific contractual and residual mix LCI	• Inventories of activity data: **free choice or imposed sources** • **Perimeter** of steps to be included in or excluded from the inventory. • Existence or not of requirements or recommendations for modelling contractual mixes based on REN and residual mix. • Rules or no rules for framing cases of **EAC certificates not linked to electricity and partial.** • Rules or no rules for framing the **temporal validity of specific contractual instruments.**

THEMES AND KEY POINTS OF THE REFERENCE FRAMEWORK ANALYSIS GRID.

This inventory allows highlighting several important observations, detailed below.

General stance of reference frameworks regarding the Market-based approach

▶ The "product" oriented reference frameworks examined are strongly aligned with ISO 14067 and the GHG protocol, and dominate the principle of the Market-based approach.

▶ Much more contrasted stances are observed among the "Organisation" oriented reference frameworks, several of which demand the application of the Location-based approach, or a rationale or dual reporting.

"Product" oriented reference frameworks	Location-based	Market-based
Required		7
Recommended	1	
Possible	1	2
Not authorised except in specific cases / exceptions	6	
Not authorised	1	

"Organisation" oriented reference frameworks	Location-based	Market-based
Required	4	2
Recommended	2	
Possible	2	4
Not recommended but possible		1
Not authorised	1	2

Choice of electric mixes according to life cycle step

▶ The explicit or possible coexistence of Market-based and Location-based approaches for the same study, without reference frameworks positioned on the requirement of an acceptable level of consistency or inconsistency.

For certain "product" reference frameworks advocating the Market-based approach, recourse to the Location-based method is not excluded however, since its utilisation remains possible when residual mixes are not accessible and are even required by PEF/OEF for the utilisation phase.

These frameworks do not provide further guidelines for this possible coexistence of the two approaches within the same assessment.

Regarding many reference frameworks, note should also be made of an absence of explicit and univocal rule relating to the choice of electricity mixes in the case of avoided electricity through ends of life and the management of production wastes (e.g., recycling, energy recovery).

Contractual instrument eligibility criteria based on REN attributes

▶ Non-discriminatory or weakly constraining criteria: types of contractual instruments accepted, temporal concordance, nature of attributes expected.

▶ Criteria whose conditions of conformity are more or less strict and precise: single ownership of attributes, spatial concordance.

The typology of eligibility criteria is generally similar between the reference frameworks examined. The criteria and the conditions to be conformed with to satisfy them are more precise in the PEF/OEF and in the GHG Protocol compared to ISO 14067.

The result is that certain criteria are non-discriminatory or weakly constraining.

- The **nature of contractual instruments** is not a discriminating criterion, since all types of instruments are accepted by the different reference frameworks.
- The reference frameworks require that temporal **concordance be** "as close as possible". This blurred notion leaves much room for interpretation and reduces the pertinence of this criteria.

- Regarding the **nature of the environmental attributes expected**, ISO 14067 does not mention specific attributes, preferring a general formulation.

For other criteria, the conditions to be conformed with to satisfy them are more or less strict and precise.

- The exclusive ownership of attributes is a crucial criterion that seems not to be guaranteed in countries with multiple certificate systems. The PEF/OEF and GHG Protocol frameworks set out this case, but ISO 14067 does not. None of the reference frameworks goes as far as identifying the countries/markets for which this criterion is not guaranteed *de facto*.
- The spatial concordance between the contractual instruments and the electricity consumption to which they are attached is expected on the scale of the market or country according to the reference frameworks. The notion of market can represent challenges of interpretation, especially in the case of Europe, since the reference frameworks shed little light on this issue (e.g, Poland does not belong to the European market according to the Market boundaries criteria of initiative RE100).

There is no criterion of eligibility concerning the age or the mode of financing renewable electricity production installations.

Rules for modelling contractual mixes based on REN attributes

▶ There are few requirements or recommendations in the reference frameworks for guiding the modelling of specific REN contractual mixes or residual mixes.

With few exceptions, the reference frameworks examined do not impose inventories or sources of activity data to model residual mixes or specific contractual mixes. The PEF is an exception but with partial guidelines since residual mixes will at best be available for countries located in Europe; also, only elementary modelling blocks should be mandated for specific contractual mixes (individualised LCI by technology/country).

Regarding the **perimeter of the steps to be taken into account**, at best the frameworks set out general principles: the steps upstream, the generation step, the steps downstream. For example, the need to consider or not the infrastructures of electricity production units and networks (construction and decommissioning) is not explicitly dealt with in the reference frameworks.

The reference frameworks set out **few requirements or recommendations for guiding the modelling of contractual mixes**, whether specific or residual. In the case of specific mixes, certain subjects of interest are not clearly set out:

- The cases where the physical electricity consumed and REN attributes are dissociated and where the latter do not cover all the electricity consumed.
- The accounting of grid losses: as certificates can be issued for a quantity of electricity injected into the grid (without taking account of later losses due to transport to the users if our understanding is correct), this raises the question of the production sources that have to be considered to model these losses.

Frameworks such as PEF or ISO 14067 do not include specific requirements relating to the **temporal validity of contractual instruments** and thus studies, which may be very limited (punctual purchases of unbundled certificates) or on the contrary very long (e.g., Power Purchase Agreement with a commitment for several years). However, requirements are set out by the International EPD® System and the draft standard prEN 15941: 2022, as the principle put forward is that the declaring entity undertakes to purchase certificates throughout the period of validity of their EPD and to declare any change in using the contractual instruments.

C.3 MARKET-BASED APPROACH TO LCA: KEY LESSONS FROM THE CASE STUDY

Using a market-based approach leads to a heterogenous variation of indicators according to country, some upwards, some downwards. Countries that are big producers and exporters of GOs appear to be more sensitive to this variation, as in the case of Norway.

Despite this, these results show that the application of residual mixes tends to increase impacts linked to the use of fossil fuels, especially the indicator of total climate change.

Regarding the climate change indicator, the application of a market-based approach or a location-based approach may lead to a different ranking of contributors. Likewise for the application of a “hybrid” approach, combining both approaches in the same study.

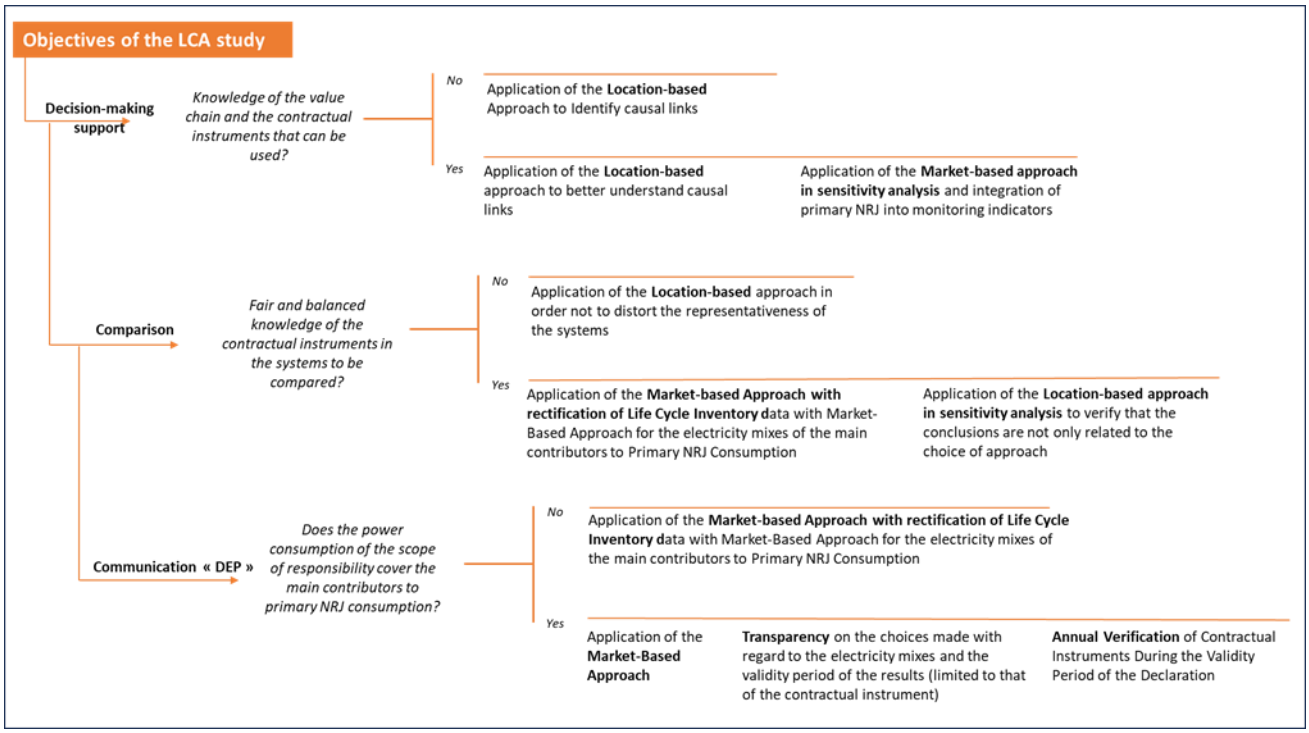
When electricity production from renewable sources (for the application of GO) is considered, the exclusion of infrastructures in the environmental analysis leads to a significant underestimation of the climate change indicator, and more generally of the other indicators, in varying degrees.

Regarding the modelling of specific contractual mixes (with GO/EAC), the choice of the electricity mix to offset electricity transport and distribution losses also has an influence, though less significant than that of infrastructures. The utilisation of a residual mix to offset these losses tends to increase the results for the climate change indicator.

D. RECOMMENDATIONS

D.1 CHOICE OF APPROACH ACCORDING TO CONTEXTS OF APPLYING LCA

The following figure shows the main recommendations for applying the Market-based approach in LCA according to the main goals of the studies[2].



The study concludes with methodological recommendations for the implementation of the **Market-based approach** for various contexts of application. They are synthesised in the table below:

Objectives of the study	Challenges of the Market-based approach	Recommendations
Eco-design works R&D on new products, new processes	▪ Little known or unknown information relating to the value chain and conditions of use of the product or service. ▪ Risk of systematically applying residual electricity mixes for a Market-based approach. ▪ Need to identify the links of causality.	To be avoided
Aid for the optimisation of products/services	▪ Care is needed to avoid the temptation to reduce only the result of the carbon footprint by using contractual electricity of guaranteed origin. ▪ Need to incorporate the total primary energy consumption to assess the level of dependency on renewable energies and monitor efforts to achieve energy sobriety. ▪ Need to identify links of causality.	Privilege the Location-based approach
Aid in choosing a solution	▪ Major risk of generating a distortion of representativeness of competing systems with the Market-based approach.	If the guarantee of equal treatment between systems is demonstrated.

[2] We remind that in the framework of this study, only the application of the Market-based approach to electricity mixes in LCA considered attributional is dealt with.

Objectives of the study	Challenges of the Market-based approach	Recommendations
Comparative assertion intended for the public	▪ Need to check that the positioning between solutions is not linked only to the way electricity is modelled. ▪ Period of validity subject to the duration of validity of contractual instruments.	With a Location-based analysis. With rectification of electricity inventories. With limited lifetime duration of results.
Environmental communication based on LCA **(e.g., EPD/product footprints)**	▪ Need to reduce hybridisation in the way to model electricity mixes. ▪ Need for transparency regarding the choices made. ▪ Uniform application of the approach within the declaring entity.	With rectification of the inventories. Associated with transparent communication of the choices made.

RECOMMENDATIONS ON THE APPLICATION OF THE MARKET-BASED METHOD AS A FUNCTION OF CONTEXTS OF USE.

D.2 MARKET-BASED APPROACH: METHODOLOGICAL AND IMPLEMENTATION RECOMMENDATIONS

The study formulates methodological and implementation recommendations for Environmental Footprint and Environmental Product Declaration applications that are the most likely to implement the Market-based method. These recommendations concern:

- The choice and ranking of electric mixes.
- The modelling of specific contractual mixes based on contractual REN attributes.
- The eligibility criteria of contractual instruments.

These recommendations are detailed in the following sections.

D.2.1 CHOICE AND RANKING OF MIXES

Three methodological principles guided the formulation of the recommendations proposed.

The requirement for methodological consistency

Methodological consistency is part of what is expected from the general standards ISO 14040: 2006 and ISO 14044: 2006 that frame the performance of LCA. This must be expressed through the methods, data and hypotheses applied consistently throughout a study.

The challenge of double counting

The coexistence of the Market-based and Location-based approaches in the same study leads to the double counting of “contractual” REN electricity. In application of the principle of consistency, the modelling of the electricity “grid” in the same LCA must be based on a single method.

In practice, strictly conforming to this basic principle may prove difficult or impossible in the case of works opting for the Market-based approach. If full consistency cannot be reached, this raises the question of up to where is it advisable to adapt the modelling the background data which are by default modelled with the Location-based approach?

In every case, it is important to ensure that the electricity of the remaining steps modelled with the Location-based approach is not a significant contributor whose modelling choice can influence the conclusions.

The challenge of representing individual contractual choices accurately

The Market-based approach relies on the singularisation by consumer of the electricity impact profiles. It is necessary to take these individual choices into account to obtain an accurate representation.

This nonetheless involves accessing specific information for activities that go far beyond the direct control of an entity wishing to carry out an LCA.

When knowledge of individual choices is not accessible or not sought, one possibility is to apply the residual mix. This option allows avoiding the double counting of “REN” certificates but does not necessarily allow accurately representing the contractual choices actually made.

The barely contributing nature of steps remaining modelled in the Location-based approach

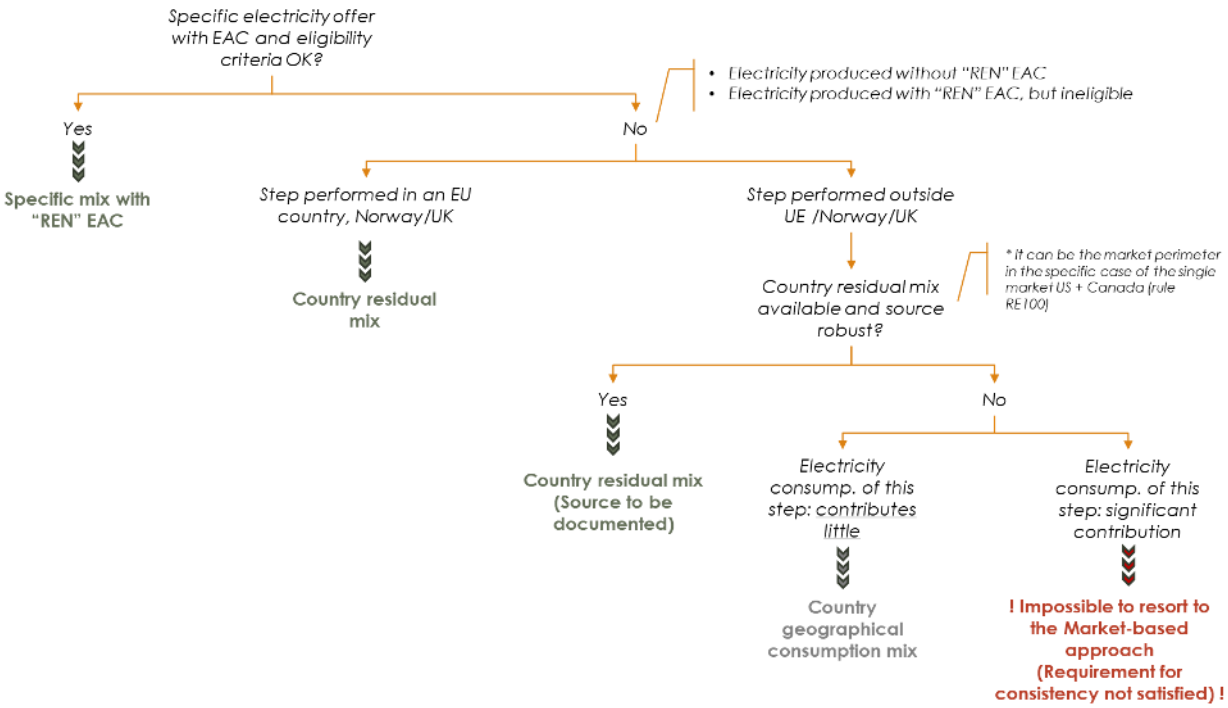
This appreciation must be understood not step by step but by understanding the **aggregated contribution** of the steps involved, whether they are steps controlled or not by the entity performing the study.

This aggregated contribution of the electricity of these steps merits examination with respect to: i) the parameters linked to primary energy consumption and the contribution of all the electricity to these indicators of physical flows; ii) the impact indicators studied.

Regarding the methodology to be implemented, the threshold values to be satisfied must ideally be established by frameworks governing EPD and product footprints for general principles, and by Product Category Rules (PCR, PEFCR) relating to the thresholds and instructions of implementation adapted to the specific characteristics of a category of products.

If such rules are not available in a PCR, the person carrying out the study must define an approach and demonstrate that the nature of the steps that remain modelled with the Location-based approach contributes little.

Steps under the control of the entity carrying out the assessment: principles and flowchart.



DECISION FLOWCHART FOR STEPS UNDER THE CONTROL OF THE ENTITY CARRYING OUT THE LCA.

Principles:

- A specific electricity offer can correspond to a "turnkey" electricity product or an electricity product completed by the purchase of unbundled certificates (in conformity with eligibility criteria).
- If the electricity product does not contain contractual attributes making it possible to claim the electricity production resources (e.g. REN origin) or in the case of an electricity product not satisfying the eligibility criteria, the residual mix of the country must be used to model the electricity consumption of the step.

  NB: the localisation of the steps under control is known to the entity carrying out the works and must be established on the scale of the country or countries concerned.
- Recourse to the modelling of electricity based on a location-based mix must be limited to the steps:
  - performed outside Europe in countries for which the residual mix is unavailable;

- whose electricity consumption contributes little to environmental impacts.

! If the latter criterion is not fulfilled, the requirement for methodological consistency is not satisfied and the Market-based approach must not be used in the study. The study must therefore be carried out wholly according the Location-based approach!

Comments:

- At present, the main databases of life cycle inventories propose datasets of residual mixes only for countries of the European Union.
- The I-REC association announced in 2023 that it was developing a methodology for calculating residual mixes that can be applied to countries issuing I-REC certificates.
- The European mix should not be confounded with the European Attribute Mix which is a intermediate step for establishing (final) residual mixes by country.

Utilisation phase

For reasons of methodological consistency, this step – if in the scope of a study – must be modelled according to a market mix and not according to a location-based approach.

Having recourse to a residual mix could lead to overestimating the impact of the utilisation phase since it overlooks the fact that electricity consumers may have contractual instruments allowing them to claim electricity produced from renewable sources.

Opting for the total mix of the suppliers of a country does not appear to be adequate neither since it does not avoid the risk of double counting REN certificates[3].

An alternative approach is to consider a **scenario-based approach.** One argument used by those promoting the market approach is its strong “decisional” value and its capacity to empower consumers regarding their individual choices of purchasing. Rather than wanting to represent an average utilisation profile, particularly difficult to establish, one angle to be considered is to take account of the influence that different purchasing positions can have on the results of an assessment.

In the context of product footprints or EPDs, the utilisation phase could be presented with a dual profile: one scenario with “electricity offer, 100% REN certificate” and another with “electricity offer, 0% REN (residual mix) for example. In the case of a low contribution of the utilisation phase, it would nonetheless be acceptable to simplify the model by using the residual mix of the country.

Other steps not under the control of the entity: principles and flowcharts

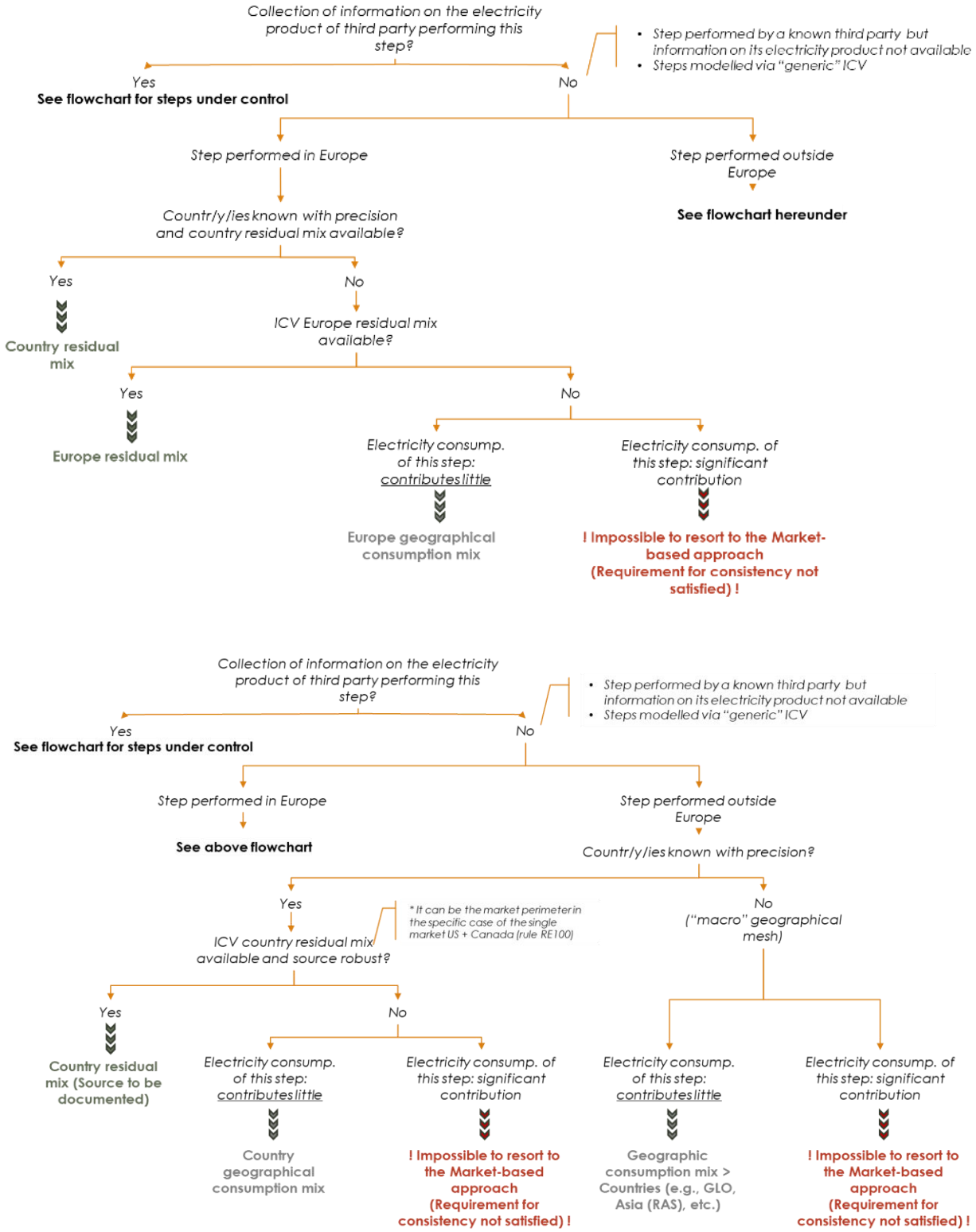
The study recommends the use of the following decision flowcharts.

Principles:

- When possible and relevant to contributive steps, the collection of specific information on the individual contractual choices of suppliers and partners should be privileged. The flowchart described for the steps under control is applicable to these situations.
- Recourse to a model of electricity based on a location-based mix must be limited to steps:
  - whose geographic representation is approximative and refers to major regions of the world (e.g., Europe, Asie, etc.), without it being possible to have greater geographical detail on the scale of countries;
  - performed in clearly identified non-European countries but for which residual mixes are not available;
  - whose electricity consumption contributes little to environmental impacts.

[3] The Total Supplier Mix is based on the total electricity consumption of a country; it also encompasses both households, industrial sectors, tertiary activities, etc. However, it is possible that the average purchasing profiles specific to these different types of consumers are different.

! If the latter criterion is not fulfilled, the requirement for methodological consistency is not satisfied and the Market-based approach must not be used in the study. The study must therefore be wholly performed according to a Location-based approach!



DECISION FLOWCHART FOR THE STEPS NOT UNDER THE CONTROL OF THE ENTITY PERFORMING THE LCA.

The case of electricity avoided during the end of product life

The reference frameworks examined do not explicitly deal with the principles of modelling electricity avoided in relation to energy recovery and recycling. However, **modelling avoided electricity raises specific and even difficult methodological questions**.

Some products have a long lifetime, with their orientation to energy recovery, recycling, etc. occurring many years after their production: thus, how can avoided contractual electricity be taken into account, especially for distant temporal horizons?

There is no obvious answer to these questions. In all cases, the choice of a residual mix to represent this avoided electricity is likely to maximise the avoided impacts of electricity without real basis and is therefore inadequate.

More generally, the relevance of using a Market-based approach for assessments taking account of avoided impacts through recycling or energy recovery may be questioned, especially as material circularity issues are becoming increasingly important.

The authors of this study encourage the developers of frameworks advocating the Market-based approach to consider the challenges raised by accounting for avoided electricity and formulate well-argued methodological proposals open to discussion.

D.2.2 MODELLING SPECIFIC CONTRACTUAL MIXES WITH REN ATTRIBUTES

There are few specific guidelines for LCA professionals who have to model a specific contractual mix based on REN technologies. Recommendations for establishing this type of specific contractual mix are proposed and summarised below.

Guidelines for modelling specific contractual mixes

The guidelines formulated for modelling REN specific contractual mixes rely on the following methodological principles:

- **Perimeter to be considered:** the lifecycle inventories of electricity production from renewable energy sources must include the production, maintenance, and end of life of infrastructures. Moreover, processes linked to electricity transformation and transport (losses of electricity during its transformation and transport, production, maintenance, and the end of life of electricity transformation and transport infrastructures as well as the specific emissions of these activities) must be modelled;
- **Completeness of lifecycle inventories:** lifecycle inventories must render account of flows of materials and resources that are pertinent and specific to each technology (e.g., rare earths for wind power, land-use for solar power, etc.);
- **Technological representativeness:** the technological concordance of the attributes of contractual electricity and available lifecycle inventories in the databases of LCI must be demonstrated and justified. Recourse to a "proxy" approach or the ad hoc modelling of the electricity production technology may be required but it must be transcribed and justified transparently in the study report;
- **Geographic representativeness**: geographical concordance between the physical electricity consumed and the emission zone of the attributes claimed must be demonstrated and justified;
- **Temporal representativeness**: the temporal concordance between the physical electricity consumed and the period of validity of the attributes claimed must be demonstrated and justified;
- The environmental attributes of the contractual electricity **should be assigned to all the production of the site consuming the electricity** over the period covered and not to a fraction of the production. Furthermore, if the real electricity consumption of the site is higher than the contractual volume of electricity, the surplus electricity consumed and not covered by the REN EAC must be modelled with the residual mix;
- If a Market-based approach is chosen, it must be applied for all the production sites under the control of the entity that performs the LCA, whatever the localisation of the production sites (no cherry picking allowed).

Step	Information to be collected	Implementation	Potential sources
REN electricity production	One or more production technologies covered by the contractual instrument	• For each contractual item: the quantity or share of the contractual electricity for each electricity production technology included in the package of the supplier(s).	• EAC certificates or electricity supplier
	Localisation of production units	• The geographic origin of the electricity produced is specified in the energy attributes certificates	• EAC certificates or electricity supplier
	Temporal representativeness	• Ensure that the period covered by the contractual item corresponds to the period when electricity consumption occurs at the purchaser's site(s)	• EAC certificates or electricity supplier
	Choice of lifecycle inventories	• Identify the lifecycle inventories corresponding to the technologies included in the specific contractual mix. • OR: If available, collect directly from the supplier the life cycle inventory of the specific contractual mix or specific technology. • In both cases: – check that the perimeter includes **the production and end of life of the infrastructures,** – check the effective inclusion of **certain flows of materials or resources pertinent and specific** to each technology.	• LCA databases • Electricity supplier (if the supplier mix inventory or the production technology is available)
Losses during electricity transformation and transport	Volume of electricity losses	• For each contractual item: the quantity or share of contractual electricity for each electricity production technology included in the package of the supplier(s).	• LCA databases • IEA publications, etc.
	Breakdown of losses at each level of voltage	• Based on the approaches implemented in the LCA databases	• LCA databases
	Geographical representativeness	• The losses must be representative of the country in which the electricity consumption site is located.	•
	Temporal representativeness	• Ideally, it should correspond to the period covered by the contractual item, • Use the most recent data published.	• IEA publications or equivalent • Or LCA databases
	Choice of lifecycle inventory to model losses	• **By default, losses must be modelled according to the residual mix of the consumption of the country of** localisation. • If proven that the contractual instrument accounts for grid losses or if the purchase of GO/EAC is higher than consumption to account for the grid losses: specific contractual mix. • Any recourse to another electricity mix must be duly justified.	• LCA databases
Transformation and transport infrastructures: production, maintenance, and end of life	Choice of lifecycle inventory	• Data on the transformation and transport infrastructures used (quantities and type of materials, inputs and outputs linked to the maintenance of infrastructures, emissions of N_2O, SF_6, ozone, etc.). • Based on the model proposed in the main databases	• LCA databases (see their documentation)

D.2.3 ELIGIBILITY CRITERIA OF REN CONTRACTUAL INSTRUMENTS

Nature of environmental attributes	Nature of accepted contractual instruments
Implementation	

• Attributes = mix of REN production technologies concerned and their geographic locations
• Technologies:
  ◦ Must have: major REN technological families (wind, solar, etc.)
  ◦ Nice to have: subcategories of the same technological family
• Geography: country of issue of the attribute
	To date, all the contractual instruments are eligible, which leads to debate.
	Limiting or not the nature of contractual instruments raises questions of methodology and value choice in the meaning of ISO 14044:2006 which calls for a large-scale decision-making process (EU, ISO, governance of the GHG Protocol, etc.).

Transparency	
• Render account of the environmental attributes effectively claimed for each step concerned (under control or not). • Specify the sources of information that led to establishing this information.	• Document the nature of the contractual instruments used. Recourse to unbundled EAC must be explicit. • Transparency expected for the steps under control or not.

Single ownership of attributes	Absence of double claim of attributes
Implementation	
• Show that all the environmental attributes are effectively held by the entity and that they are not liable to be held by other actors. • Rely on documentary resources and the expertise of structures such as the International REC Standard Foundation or the RE100 initiative.	• If the contractual instruments concern countries outside the European Union, it is recommended to make sure that rules and systems are in place to ensure compliance with the criterion of absence of double claims.
Transparency	
• Show that this criterion is fulfilled when the contractual instruments concern countries outside the European Union and the US. • Transparency expected for steps under control or not.	• Documente the items collected that permit documenting compliance with this criterion. • Transparency expected for steps under control or not.

Spatial concordance	Temporal concordance
Implementation	

• It is recommended to comply with the criteria of the RE100 initiative with respect to Europe.
• “EU market” if the 3 criteria are met:
  ◦ The country belongs to the EU single market,
  ◦ The country is a member of the AIB,
  ◦ Connection with the grid of another country complying with the first two rules.
• Individual market: UK, Romania, Bulgaria, Poland.
	To date, this criterion has been relatively lax.
	Changing the rules relating to the lifetimes of EAC and to the temporal concordance between physical consumption and contractual provisions implies discussing the provisions and underlying value choices in the framework of a large-scale decision-making process (EU, ISO, governance of the GHG Protocol, etc.).

Transparency	
• Render account of the geographical localisation of steps with REN contractual electricity. • Explain how this criterion has been met. • Confirm monitoring of recommendation RE100 for the EU. Clearly indicate and justify differences.	• Document the time step used to match the physical consumption of electricity and contractual claims (annually, hourly, etc.). • Document the duration of validity of the EAC/GO used.