Status and Trends Report on U.S. Energy Attribute Tracking Systems

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Introduction

Tracking systems in the United States have evolved quickly over the past two decades. Utility regulators have learned that tracking energy attributes offers a simpler way to support usage and ownership claims to renewable energy than more difficult alternatives, such as tracking contracts or tracking physical electricity. Systems that track energy attributes are responsible for issuing energy attribute certificates (EACs) and managing their transfer and ownership until the certificates are retired or claimed. Tracking systems—also called registries—do the critical work to establish ownership rights and credibility for the many market participants that trade in EACs. The first tracking system was launched by Texas in 2001, and there are now nine primary systems in operation in the United States. They track compliance with renewable energy mandates, provide power source and emissions disclosure information to consumers, and track ownership of certificates to support voluntary procurements and energy usage claims. In all these applications, a major objective has been to avoid double counting: no double issuance of certificates based on the same megawatt-hours (MWh) and no double claims on the same certificate or unit of generation. Tracking systems have succeeded in supporting this outcome.

In New England and Texas, state regulators gave their support to develop the first digital registries to issue certificates and track them from generation sources to those who ultimately claim them. As newer tracking systems were developed, they tended to emulate many features of those that preceded them, with the result that each system is similar in organization, capabilities, and sometimes even operating procedures or definitions. As each registry was commissioned, however, they adapted to the unique requirements placed on them by the variations in state statutes such as renewable portfolio standards (RPS) and other renewable energy laws.

Each tracking system has focused on the needs of the states and stakeholders it serves. Each system has its own governance, which may be a single public utility commission or state agency, wholesale market operators, a private nonprofit company, a for-profit company, or a consortium of states and other stakeholders.

As state policy direction and legal requirements have evolved and added new or differing responsibilities to the tracking systems, the registries have to some extent differentiated or grown apart to better serve their constituents.

In addition to public policy drivers, voluntary markets have been a focus and important market driver almost from the beginning, bringing a broader set of stakeholders and interests. Market demand for renewable electricity or emission-free electricity has grown to the point where it appears that voluntary demand for renewable energy certificates (RECs) may be about to overtake RPS or compliance demand. Voluntary market players also drive interest in new capabilities, such as granular certificates.

The range of stakeholders engaging in the voluntary green power market continues to grow. The federal government has also had an interest in the operation of tracking systems. Its goals have been to support federal public-facing programs, such as the U.S. Environmental Protection Agency's (EPA's) Green Power Partnership (GPP); programs focused on the internal operations of

federal agencies, such as the Department of Energy's (DOE's) Federal Energy Management Program (FEMP); and successive Executive Orders (EOs) requiring agencies to procure clean electricity. More recently, the Inflation Reduction Act and the Infrastructure Investment and Jobs Act (also known as the Bipartisan Infrastructure Law) include provisions for tax credits and program support for the procurement of low embodied construction materials that rely on energy attribute tracking systems to verify that manufacturers meet eligibility criteria.

As nation-wide programs addressing clean energy become operational, there is a growing urgency to ensure equal treatment of electricity generators and market participants among tracking systems. Harmonization of tracking system rules, if not consistency across tracking systems, is important to maintaining the integrity of electricity attribute markets. Functional capabilities, rules, and procedures should be considered, including definitions, electricity and emissions measurement protocols, independent verification, certificate issuance and retirement, and system interoperability. Tracking systems have a broader range of stakeholders than ever before and a wider variety of needs to be satisfied. The risk is that programs and policymakers will develop registry alternatives if current tracking system infrastructure is unresponsive or unable to meet new and emerging trends in the market.

This report is an attempt to articulate the status and needs of the current tracking system infrastructure, and to initiate discussion about how best to meet the need for additional capabilities as well as procedural harmonization across tracking systems. It is organized as follows:

- **Section 1** provides an overview of what energy attribute tracking systems are and why they were developed. It also summarizes how tracking systems operate as well as some key similarities and differences among them.
- **Section 2** looks more closely at current trends in U.S. energy markets that are driving tracking systems to evolve, and at the steps registries are already taking to address and prepare for future needs.
- A **Conclusion** discusses the critical work of tracking systems to date in supporting credible energy markets and why these systems might further evolve and harmonize to serve emerging market interests and policy needs.
- **Appendix A** explores a hypothetical "North Star" of tracking system capabilities and functionality driven by a set of emerging trends, policies, programs, and standards—domestic and abroad—that present material opportunities and challenges for U.S. businesses and multinationals.

1. Introduction to energy attribute tracking systems

1.1 What are energy attribute tracking systems?

Energy attribute tracking systems are digital web-accessible platforms that register basic information about each MWh of electricity generation in a specific geographic region.[1] For each MWh of electricity delivered to the grid, these database systems electronically "mint" or issue EACs to the owner of the generation facility. Some tracking systems account for attributes from all types of electricity generation; others only account for attributes of renewable electricity generation. Each EAC issued by a tracking system is assigned a unique, traceable serial number and includes specific information on the representative energy attributes. The attributes accounted for by tracking systems include the characteristics of the electricity generator (tracked with static data) and the generator's electricity output over time (tracked with dynamic data). Typical types of static data include the generator's fuel or energy source (e.g., wind), its location (e.g., state), the year it commenced operation, and its nameplate capacity in megawatts (MW). Typical types of dynamic data include the date of generation (month and year), volume of generation (MWh), and the generator's eligibility for voluntary and state compliance programs.

EACs are tradeable assets representing property ownership[2] of the attributes of electricity generation. Ownership of EACs provides the legal basis for consumers' claims about the electricity they have used. All EACs are traded independently or "unbundled" from the underlying electricity.[3] RECs,[4] a type of EAC specific to electricity generation from renewable energy sources,[5] have been called a "necessary part of the machinery of U.S. electricity markets, used to demonstrate renewable electricity purchasing, delivery, and use"[6] and have been recognized as a "tool to pursue policies that support decarbonization of the electric grid."[7] Through the electronic issuance of RECs, tracking systems help bolster market credibility and the liquidity of RECs for various compliance and voluntary market applications.

EACs are generally issued to electricity generating facilities that are registered in the tracking system, based on MWh production volumes. Larger generating facilities may produce multiple

[1] Tracking systems are also widely used in Europe as well as internationally across many countries and markets.
[2] Renewable energy credits as property. (2024). *Harvard Law Review, 137*(3). https://harvardlawreview.org/print/vol-137/renewable-energy-credits-as-property
[3] A "bundled" purchase is one in which the buyer purchases both the EACs and physical power from the same supplier. Note that, because physical electrons cannot be traced, tracked, or directed to a buyer on a shared grid, the buyer generally cannot be assured it receives the exact physical power produced by the generator when the EAC was issued.
[4] While some states and market participants use different names for RECs (e.g., "renewable energy credits," "alternative energy credits"), the term generally refers to a tradeable certificate representing the attributes of one MWh of renewable generation.
[5] Renewable generation is defined as energy generated by a facility that is considered a renewable energy source as defined by any state or province using the tracking system.
[6] Center for Resource Solutions. (2023). *The legal basis for renewable energy certificates*. https://resource-solutions.org/wp-content/uploads/2015/07/The-Legal-Basis-for-RECs.pdf
[7] Renewable energy credits as property. (2024). *Harvard Law Review, 137*(3). https://harvardlawreview.org/print/vol-137/renewable-energy-credits-as-property

MWh in a particular hour or day, whereas smaller facilities may take days or weeks to produce a single MWh. Once EACs are issued, account holders can transfer them to other account holders, in some cases export them to other tracking systems, or retire them. Tracking systems electronically trace ownership of EACs between account holders and remove EACs from circulation when they are retired, which prevents double counting of the same energy attributes. Tracking systems do not generally contain any price information on EACs,[8] and while the systems account for the transfer of EACs between account holders, the financial settlement is transacted outside the tracking system infrastructure. Power purchase contracts are also executed outside tracking systems, though the transfer of EACs within the tracking system helps the parties validate the contract terms and conditions.

At present, there are nine[9] tracking systems in North America, which together provide full coverage of all U.S. states:

- Electric Reliability Council of Texas (ERCOT)
- Michigan Renewable Energy Certification System (MIRECS)
- Midwest Renewable Energy Tracking System (M-RETS)
- North American Renewables Registry (NAR)
- North Carolina Renewable Energy Tracking System (NC-RETS)
- New England Power Pool Generation Information System (NEPOOL-GIS)
- New York Generation Attribute Tracking System (NYGATS)
- PJM EIS's Generation Attribute Tracking System (PJM-GATS)
- Western Renewable Energy Generation Information System (WREGIS)

The map in Figure 1 shows the tracking systems' footprints within the United States. Five the nine systems cover multi-state areas (M-RETS, NAR, NEPOOL-GIS, PJM-GATS, and WREGIS) and four are single-state systems (ERCOT for Texas, MIRECS for Michigan, NC-RETS for North Carolina, and NYGATS for New York). Two systems (M-RETs and NAR) allow generators located anywhere in North America to register with them, while the rest require generators to be within their operational footprints.[10]

[8] The exception is PJM-GATs, which contains information on solar renewable energy certificate (SREC) prices.
[9] This report does not include Nevada Tracks Renewable Energy Credits (NVTREC), because of it is not used for voluntary market transactions and has limited functionality. As well, Nevada is already included in WREGIS's operational footprint.
[10] Several U.S.-based tracking systems serve neighboring parts of Canada and Mexico.

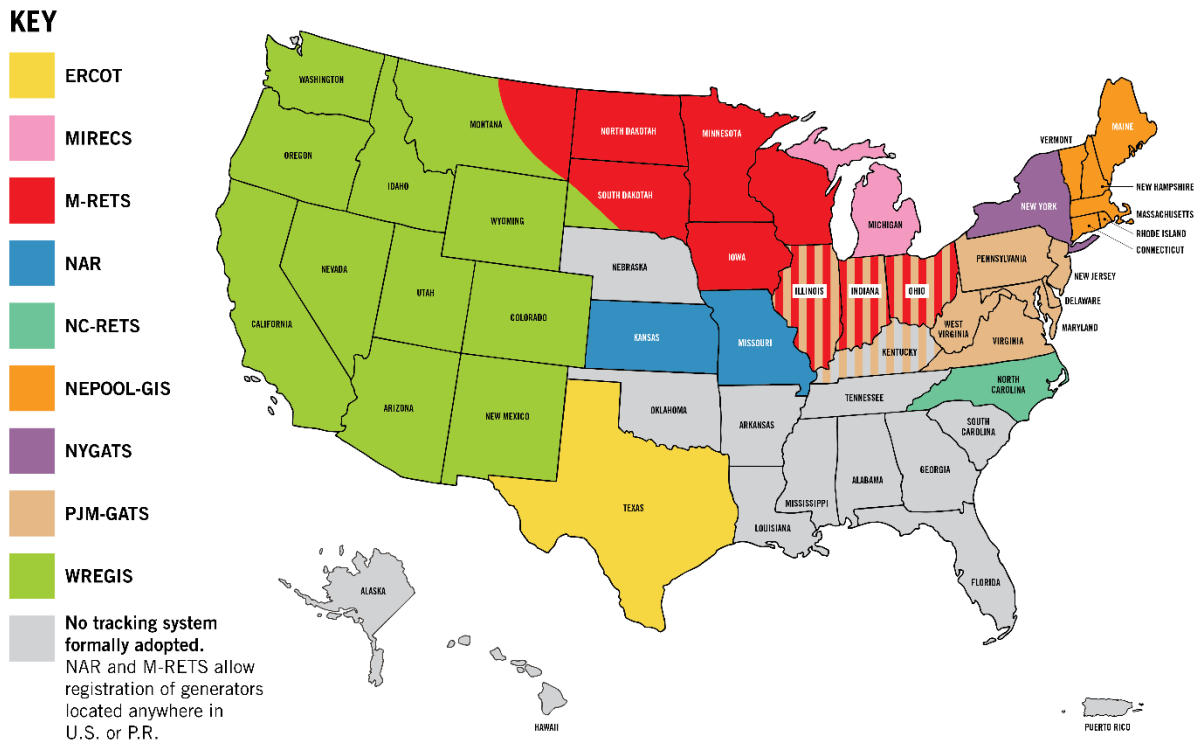

Figure 1. Map of energy attribute tracking systems.

Adapted from the Center for Resource Solutions: https://resource-solutions.org/wp-content/uploads/2018/02/Tracking-System-Map.png.

As detailed in Table 1 below, six of the systems track only renewable or clean generation as defined by the RPS or clean energy standard (CES) programs of the state(s) they cover. In some cases, the renewable or clean generation that is issued certificates by tracking systems may include generation from non-renewable sources or emitting sources if those are permitted in a given RPS or CES. The three systems in the northeast United States (NEPOOL-GIS, NYGATS, and PJM-GATS) are all-generation tracking systems, meaning they track generation from all energy sources (including non-renewable sources). M-RETS and NAR, the two systems that allow generators anywhere in North America to register, account for the largest volumes of certificate issuance.

Table 1. Overview of U.S. Tracking Systems

Tracking System	Launch Year	Type of Generation Tracked	Geographic Coverage	Number of Generators[a,b]	Number of Account Holders	Number of Certificates Issued
ERCOT	2001	Renewable	Single state	420	1,236	147,337,944
MIRECS	2009	Renewable	Single state	326	163	21,808,260
M-RETS	2007	Renewable	Multi-state/national	3,962	684	355,738,312
NAR	2009	Renewable	Multi-state/national	947	511	264,516,285

Tracking System	Launch Year	Type of Generation Tracked	Geographic Coverage	Number of Generators[a,b]	Number of Account Holders	Number of Certificates Issued
NC-RETS	2010	Renewable	Single state	1,287	668	16,039,145
NEPOOL-GIS	2002	All	Multi-state	115,632	3,234	44,609,017
NYGATS	2016	All	Single state	2,924	705	129,591,042
PJM-GATS	2005	All	Multi-state	436,583	28,100	95,316,892
WREGIS	2007	Renewable	Multi-state	11,849	1,294	N/A[c]

a. Generator totals were collected on July 31, 2024. ERCOT and MIRECS totals are from 2023. Where possible, multi-fuel generators are accounted for and have only been counted once. Some tracking systems have many small (residential) solar generators, which add to their totals.
b. Generator totals for tracking systems that track all generation include non-renewable generators.
c. WREGIS does not make its certificate totals available to the public.

In the United States, renewable energy transactions have more than tripled over the past decade, which only increases the importance and use of tracking systems to account for the generation, transaction, and final consumption and ownership of EACs. To illustrate the growth and increasing reliance on tracking system infrastructure, M-RETS issuance of certificates increased from 73 million in 2014 to 355 million in 2023, as detailed in Figure 2.

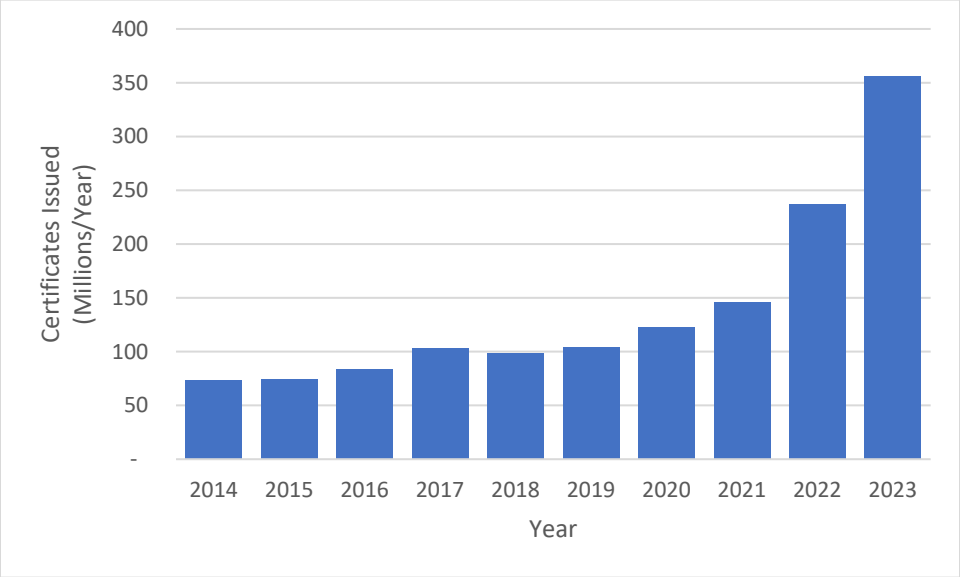

Figure 2. M-RETS certificate issuance (2014–2023).

1.2 How are energy attribute tracking system databases designed and who uses them?

Most tracking system databases follow similar architectural frameworks and provide similar functionality. Any organization wishing to access and use one must register as an account holder and create an online organizational user profile. There are typically different account holder types (often with different associated fees and annual subscription costs), generally fitting into the following categories: general organization; load-serving entity, or LSE (e.g., utility or electricity supplier); project or generator owner; program administrator; reporting entity; and

retail purchaser (typically only used by large electricity purchasers). Depending on the account holder type, the tracking system provides different levels of functionality and system access. For example, a retail purchaser account holder may be able to hold EACs, accept incoming EAC transfers, and retire EACs, but not make outgoing EAC transfers or register a generation facility. Table 2 lists the typical types of organizational users of tracking systems and describes how they use and benefit from the systems.

Table 2. Tracking System Organizational Users and Applications

Tracking System User	Application
Generating facility owner	Enhance value of clean generation and reduce transaction costs
LSE	Simplify RPS reporting and compliance and product disclosure
REC marketer	Facilitate sales; demonstrate eligibility with voluntary programs; ensure increased market liquidity
Large electricity buyer	Manage and verify EAC portfolio and retirements
Regulatory program administrator (e.g., state RPS administrator)	Reduce program administrative costs and ensure accuracy of reporting entities
Voluntary program administrator	Verify EACs meet program eligibility requirements; facilitate auditing process by streamlining chain-of-custody tracking
Qualified reporting entity	Electronically report generation data to tracking system

Tracking systems also contain accounts, which can be linked to account holders within the system. Accounts are for organizations directly involved in some part of the EAC transaction. Figure 3 shows the structure of a sample account for an organization, specifically an LSE.

Tracking systems often support both active accounts and retirement accounts, and account holders may have more than one of each.

An active account functions like a checking account. It is a holding place for the account holder's active (e.g., unclaimed) EACs, which they can transfer, retire, or export/import.

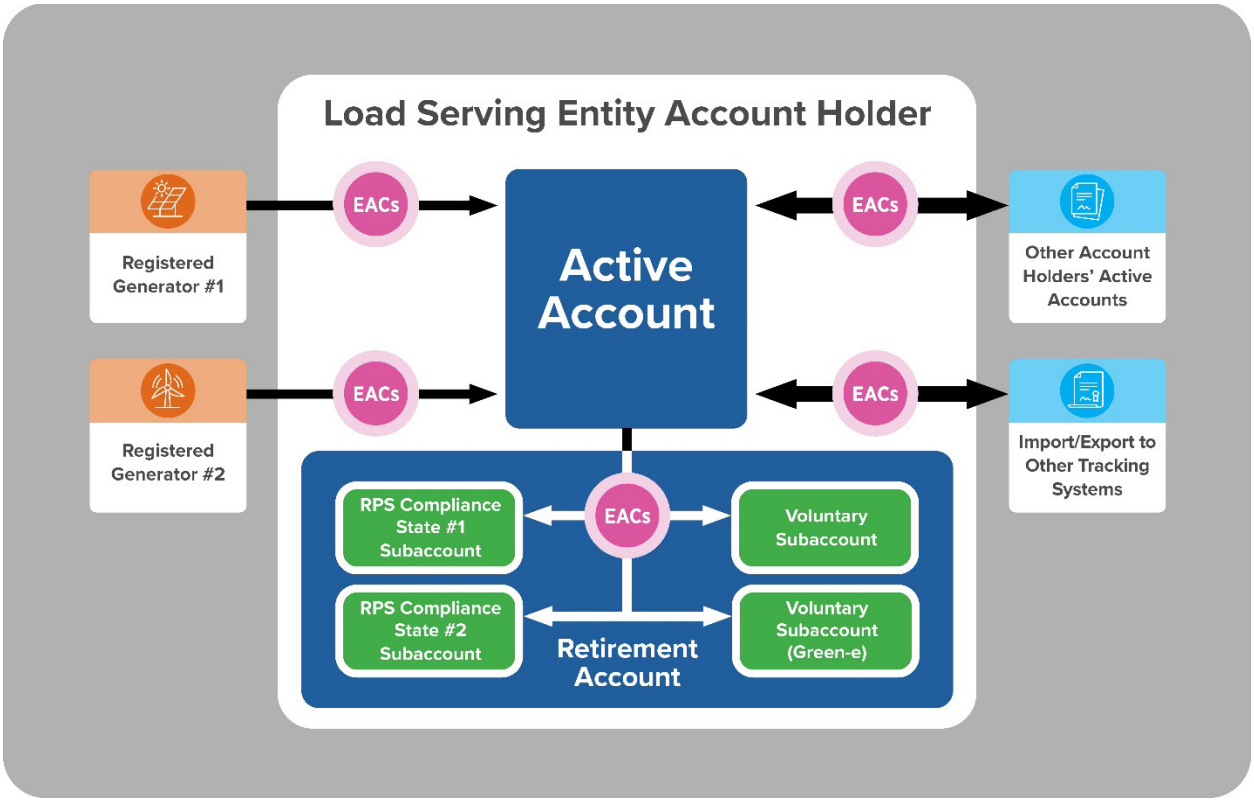

Figure 3. Conceptual example of account structure for an LSE.

A retirement account is a repository for EACs that the account holder has designated as retired. Retirement of an EAC essentially means it has been used, claimed, or consumed by the ultimate owner and consequently removed from circulation so it can no longer be used, claimed, or consumed by another party. As part of the retirement process, the account holder can often classify the reason for the retirement from a discrete set of options determined by the tracking system administrators—for example, "for compliance with a specific state's RPS," "retired on behalf of customers of a utility green power program," or "retired on behalf of a single voluntary green power consumer." Some tracking systems have special retirement subaccounts that account holders can use to deposit retired EACs, as shown in Figure 3 above. In the case of a retirement for a single retail consumer, the energy supplier or organization retiring the EACs may identify the voluntary consumer, who likely does not have a tracking system account, using the "beneficial owner" (e.g., the organization the EACs are being retired on behalf of) field within the tracking system. Once EACs are placed in a retirement account, they are no longer transferable to another party and generally cannot be unretired except in a rare set of circumstances, and then only within a brief window after being retired.

Generator accounts are created for all generators registered with the system, which assigns a unique ID number to each generator. All tracking systems publish full lists[11] of currently active registered generators, which allows other tracking systems to check that a generator is only registered in a single tracking system at a time. Such a list typically includes names (of the

[11] Generally, as a downloadable spreadsheet or online table.

generator and its owner), tracking system ID number, state location, fuel or energy resource type, date the generator commenced operation, nameplate capacity, and eligibility for state RPS programs or voluntary programs. For example, M-RETS maintains an interactive online list of generators that also allows for data download. Note that all tracking systems permit groups of small generators to register as part of an aggregation, and identified as such, within the tracking system database. These aggregate registrations come with different limitations in different tracking systems: for example, small generators being aggregated might need to share the same essential generation characteristics, be customer-sited, be within the same state, be associated with the same revenue-grade meter, or be smaller than a certain size.

In all-generation tracking systems—though this may sound contradictory—generator owners can still choose whether to register their generators. For example, the owner of a fossil-fired generator may not see value to register because there is no demand for fossil EACs and such EACs may have little economic value. To track all generation, the independent system operator or balancing authority reports generation data for all generators under its control to the tracking system, and the tracking system administrator accounts for this generation in a non-tradable administrator's account. In this manner, the attributes can still be reported and tracked, yielding information that can be used for compliance with regulations or to make environmental claims about the power purchased by a consumer.

1.3 How are tracking systems used?

Electronic tracking systems, which have existed for more than 20 years, were almost exclusively formed through direct state action, either by individual states or by coordinated groups of states.[12] ERCOT and NEPOOL-GIS were launched in 2001, PJM-GATS in 2005, WREGIS and M-RETS in 2007, MIRECS and NAR in 2009, NC-RETS in 2010, and NYGATS in 2016. These systems were originally designed to verify compliance of LSEs (e.g., utilities) with state RPSs or to support power and environmental disclosure labels for consumers.[13] They were designed to independently issue EACs using data electronically submitted by transmission control areas to ensure accuracy and avoid double counting. Most state RPS programs require compliance via use of particular tracking systems. For example, California requires LSEs to use WREGIS to track and report their RPS procurement as part of California's RPS compliance. See Table 3 for a summary of which state RPS programs use which tracking systems. RECs used for compliance with a state RPS program are retired (i.e., placed in a state RPS-specific retirement subaccount by the LSE) to remove them from circulation and ensure they are not resold or reused, as well as to help RPS program administrators verify compliance.

[12] Hamrin, J. (2014). *REC definitions and tracking mechanisms used by state RPS programs*. Clean Energy States Alliance. https://www.cesa.org/wp-content/uploads/RECs-Attribute-Definitions-Hamrin-June-2014.pdf

[13] Wingate, M., & Lehman, M. (2003). *The current status of renewable energy certificate tracking systems in North America*. Center for Resource Solutions. https://resource-solutions.org/document/the-current-status-of-renewable-energy-certificate-tracking-systems-in-north-america/

Table 3. State RPS Program Use of Tracking Systems

Tracking System	State/Territory RPS Program
ERCOT	TX
MIRECS	MI
M-RETS	IA, IL (partial), MN, ND, OH (partial), WI
NAR	KS, ME (partial), MO, NC (out-of-state generators), NY (out-of-state generators), PR
NC-RETS	NC
NEPOOL-GIS	CT, MA, ME (partial), NH, RI, VT
NYGATS	NY
PJM-GATS	DC, DE, IL (partial), MD, NJ, OH (partial), PA, VA
WREGIS	CA, CO, NM, NV, OR, UT (starting 2025), WA

Tracking systems are also used by regulators and voluntary program administrators as registries of eligible generating facilities; to aid in the creation of electricity disclosure labels; for voluntary green power certification programs (e.g., Green-e); and for other reasons, such as developing residual mixes.

Energy consumers and suppliers participating in the voluntary green power market also use tracking systems, both for wholesale and retail market transactions. Voluntary green power markets enable consumers to procure renewable electricity at levels beyond what mandatory policy decisions require and to reduce the environmental impact of their electricity use. EACs that are retired within tracking systems for voluntary purposes ensure regulatory surplus and the private claim by the ultimate consumer to the attributes of energy generation. This is true because tracking systems can clearly delineate between voluntary and compliance EAC retirements; it ensures that voluntary buyers who make investments in clean energy can credibly claim their EACs are surplus to the volume of renewable generation that would have occurred without their proactive energy procurement. EACs retired to voluntary subaccounts within a tracking system can be privately claimed by specific purchasers, whereas EACs retired by LSEs to comply with an RPS or for default product offerings are claimable by all ratepayers.

Furthermore, an increasing number of organizations rely on EACs to report emissions associated with purchased electricity use under internationally recognized voluntary greenhouse gas (GHG) accounting standards.[14] These standards require that reporting organizations demonstrate a clear claim to the attributes of delivered power, with a preference for claims based on EACs.

As depicted in Figure 4 below, retirements related to voluntary purchases of RECs accounted for 48% of the overall renewable energy market in 2023. The voluntary market is expected to grow significantly in the years ahead and could account for more than two-thirds of total U.S.

[14] Greenhouse Gas Protocol. (2015). *GHG Protocol scope 2 guidance: An amendment to the GHG Protocol corporate standard*. https://ghgprotocol.org/scope-2-guidance

renewable generation by 2026.[15] Large corporations are, and will continue to be, one of the main drivers of the growth in the voluntary market. Not only do these types of organizations rely on the tracking system infrastructure for certainty of ownership, but they often directly participate in tracking systems as account holders to manage their EAC portfolios. Where available, large purchasers often opt in to have their voluntary REC purchases disclosed publicly by the tracking system to transparently communicate their renewable energy achievements. For example, see NAR's *Retirements Disclosed to Public* report.

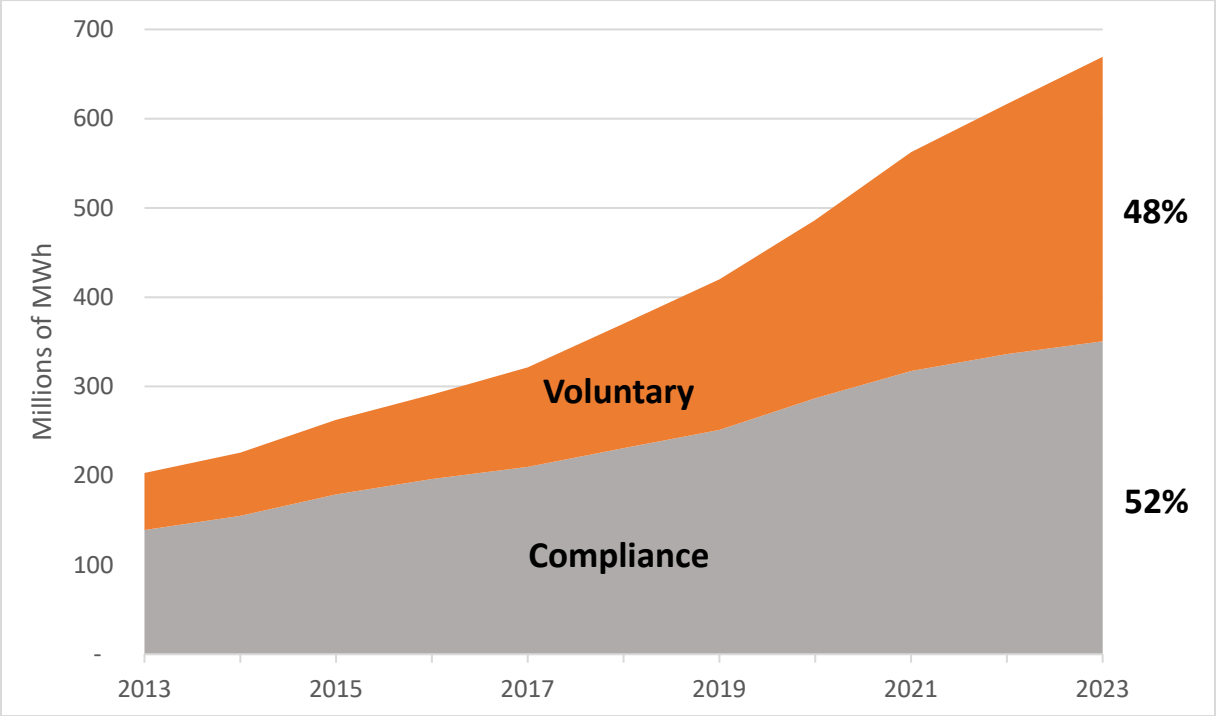

Figure 4. Renewable energy sales for voluntary and compliance purposes (2013–2023).

Data source: National Renewable Energy Laboratory (2024). The state of the U.S. voluntary green power market (2023 data). https://www.nrel.gov/analysis/assets/pdfs/status-and-trends-2023-data.pdf.

Tracking systems monitor and track transactions at the wholesale level, so the vast majority of electricity consumers (e.g., individual retail customers such as homeowners and small businesses) do not directly participate in the process since they generally do not hold accounts within tracking systems. However, retail markets give these retail customers—who cannot build or operate their own power plants—access to express their demand preferences through EACs for electricity attributes of renewable energy projects. EACs sold in retail energy markets for voluntary use may be transacted between multiple wholesale intermediaries or brokers until they are sold to retail electricity suppliers, who in turn sell them to an ultimate customer. These EACs are placed in the retirement account of the retail electricity supplier and the retirement is categorized as on behalf of the green power product's subscribers. While the tracking systems

[15] Wilson, A., & Lenoir, T. (2022, December 16). US renewable energy credit market size to double to $26 billion by 2030. *S&P Global*. https://www.spglobal.com/marketintelligence/en/news-insights/research/us-renewable-energy-credit-market-size-to-double-to-26-billion-by-2030

trace the ownership of EACs between tracking system account holders and ensure against double counting, they are not substitutes for third-party certification and verification, as chain-of-custody auditing often fails to reach the final consumer. Voluntary certification programs also rely on tracking system data to evaluate retail marketing claims and ensure that EACs are retired that support what is marketed and sold to retail customers.

Tracking systems have emerged as the best method for transparent and efficient tracking of wholesale renewable energy because they can be highly automated, include specific details about each MWh of generation, and offer 24/7 online access to market participants. Without electronic tracking systems, renewable electricity purchasers would have to rely solely on contract audits and paper attestations to confirm their unique ownership to the RECs. Electronic tracking systems significantly reduce the administrative requirements to prevent double counting.

Finally, tracking systems have adapted and expanded their capabilities over time, often in response to state RPS requirements and policy changes. As well as accounting for energy attributes, they are used to track combined heat and power, renewable thermal, demand response, and conservation and load management certificates. For example, the North Carolina Utilities Commission issues energy efficiency certificates through NC-RETS and uses the certificates to track the results of customer programs that focus on energy efficiency and demand-side management.

1.4 Tracking systems' relationship to grid operators and qualified reporting entities

In the United States, balancing authorities manage the operation of the electric system within a specific geographic area and ensure that power system demand and supply are always balanced. There are more than 60 balancing authorities in the United States, and they are typically either utilities, power marketing administrations, or groups of utilities that have formed entities called regional transmission organizations (RTOs) and independent system operators (ISOs). Figure 5 below is a map of RTOs and ISOs in the United States.

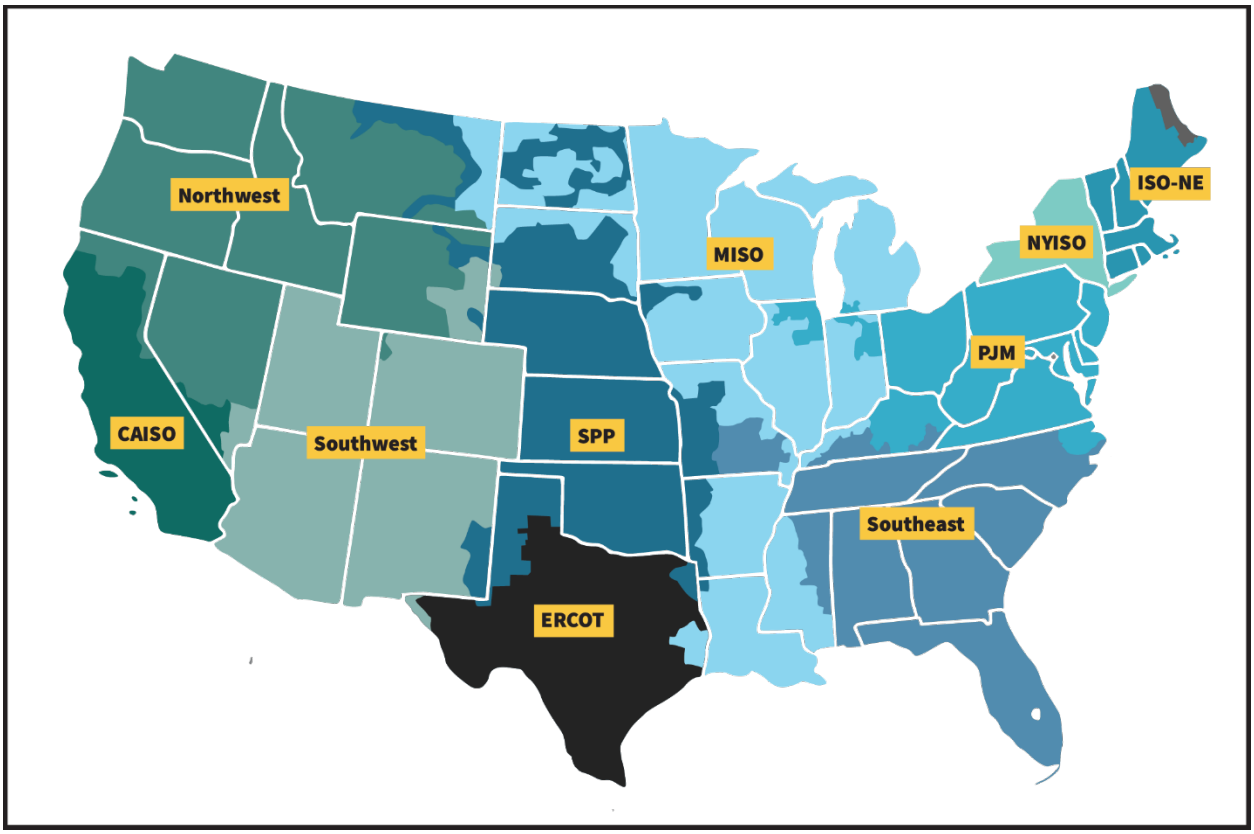

Figure 5. Map of RTOs and ISOs in the United States.

Image from the Federal Energy Regulatory Commission: https://www.ferc.gov/power-sales-and-markets/rtos-and-isos.

These grid operators are responsible for balancing supply and demand, and hence they control whether and when specific generators are dispatched and how much electricity each should generate at a given time to meet current electricity demand on the grid. They also manage the bulk of wholesale generation, typically based on generator capacity. In other words, large generators are usually controlled by the grid operators, while small, distributed generation is less likely to be similarly controlled. Grid operators report generation electronically to the tracking system monthly for each generator. If they are RTOs, they also operate wholesale markets in which generation is sold to different parties, so these transfers must be accurately measured for financial settlements. Tracking systems accept these generation data as third-party verified: that is, the grid operator is the third party. Generation from smaller generators not dispatched by the grid operator may be verified by an independent third party, often called a qualified reporting entity (QRE), that is approved by the tracking system to submit metered data. In some cases, certain eligible generators are allowed to self-report if safeguards for accuracy are followed.

1.5 Key principles and characteristics of tracking systems

Several key principles, characteristics, and procedures are foundational to the current operation of tracking systems. Many of these characteristics and existing functional capabilities can be standardized or enhanced as features are added to tracking systems in response to new

programs and evolving market needs. The following collection of principles, characteristics, and procedures helped to inform the features of the hypothetical "North Star" energy attribute tracking system detailed in Appendix A of this report.

1.5.1 Transparency

To support transparency, all tracking systems have specific public reporting requirements and procedures. Publicly available data and reports are typically accessible on each tracking system's website. The types of publicly available data are not fully consistent across the tracking systems, creating challenges when aggregating or comparing similar data across systems. All tracking systems publish their respective operating rules, generator lists, and account holders lists on their websites. Other data elements, such as the number of certificates issued and the number of certificates retired, are reported by most tracking systems. Activity statistics on system-wide data (e.g., total number of certificates issued) may be updated monthly, quarterly, or annually. Tracking systems generally require a retirement reason (e.g., for compliance or voluntary purposes) to be chosen during the certificate retirement process. NAR, a tracking system generally focused on voluntary market participants, publishes reports on voluntary REC retirements for consumers who opt in for public disclosure.

At present, tracking systems do not publish generator registration forms or the full list of data elements collected during registration, which makes it challenging to ascertain the type of information the tracking system has on a generator beyond what is conveyed on the certificate or detailed on the tracking system's list of registered generators. For example, the tracking system may collect a generator's locational latitude and longitude during registration but only detail its state on the certificate and public list. Some data are considered sensitive and are not made publicly available.

Table 4. Tracking System Characteristics Related to Transparency

Tracking System	Publish Operating Rules	Publish Generator Registration Form	Public List of Generators	Public List of Account Owners	Publish Annual Issuance Total	Publish Annual Retirement Total	Retirement Reason	Opt In Disclosed Voluntary Retirements
ERCOT	Yes	No	Yes	Yes	Yes	Yes (compliance and voluntary)	Yes	No
MIRECS	Yes	No	Yes	Yes	Yes	Yes (compliance and voluntary)	Yes	No
M-RETS	Yes	No	Yes	Yes	Yes	Yes (compliance and voluntary)	Yes	No
NAR	Yes	No	Yes	Yes	Yes	Yes (compliance and voluntary)	Optional	Yes
NC-RETS	Yes	No	Yes	Yes	Yes	Yes	Yes	No

Tracking System	Publish Operating Rules	Publish Generator Registration Form	Public List of Generators	Public List of Account Owners	Publish Annual Issuance Total	Publish Annual Retirement Total	Retirement Reason	Opt In Disclosed Voluntary Retirements
NEPOOL-GIS	Yes	No	Yes	Yes	Yes	Yes	Yes	No
NYGATS	Yes	No	Yes	Yes	Yes	Yes (compliance and voluntary)	Yes	No
PJM-GATS	Yes	No	Yes	Yes	Yes	Yes (compliance and voluntary)	Yes	No
WREGIS	Yes	No	Yes	Yes	No	No	Yes	No

1.5.2 Integrity of claims and prevention of double counting

Requirements preventing double issuance/counting

One of the key objectives of tracking systems is to verify that certificates are not double counted—for example, that certificates are not issued for generation in multiple tracking systems for the same MWh. To ensure the integrity of renewable energy claims, tracking systems uniformly require that a generator be registered in only one tracking system for issuance of certificates. Generators are also required to report 100% of the output from a registered unit, tracked in a single system.

Whole EACs

Most tracking systems require that certificates be whole, or fully aggregated, meaning that none of the energy attributes may be split off from a certificate while it is in circulation in the tracking system. All multi-state tracking systems have similar definitions of a REC and require RECs to be whole, meaning inclusive of all the GHG emissions avoidance benefits, including carbon dioxide (CO_2) benefits, associated with the MWh of renewable electricity when it was generated. This requirement relates to the fact that multi-state tracking systems were designed to accommodate multiple state RPS programs and thus need to have a broad REC definition that includes all attributes. For example, PJM-GATS defines a whole certificate as "one where none of the renewable Attributes have been separately sold, given, or otherwise transferred to another party by a deliberate act of the Certificate owner. Renewable Attributes shall include the environmental Attributes which are defined as any and all credits, benefits, emissions reductions, offsets, and allowances, howsoever entitled, directly Attributable to the generation from the Generating Unit(s)."[16]

Import and export requirements

Import and export requirements are another safeguard among tracking systems. To import or export, each system must enter into a bilateral agreement with another, in which the exporting

[16] PJM-EIS. (2024). *Generation Attribute Tracking System (GATES): Operating rules*. https://www.pjm-eis.com/-/media/DotCom/pjm-eis/documents/gats-operating-rules.pdf

system agrees to retire certificates being exported and the importing system agrees to issue or re-create certificates with the same attributes as were retired in the exporting system. Import/export transactions between tracking systems can be certificate-only (in which only the attributes of the EAC are transferred from one system to another) or bundled (in which both the energy and attributes are exchanged). Tracking systems are selective about these agreements and who they will allow imports from. One tracking system might agree to export to another tracking system but not agree to import from that system. The decision whether to accept imports/exports is likely driven by state RPS geographic eligibility rules.

1.5.3 Verification of generation

Verification requirements for generation largely relate to the question of independent verification. Generators, when they register, must provide their reports to the Energy Information Administration (EIA) and may be subject to inspection. Generating units with capacities less than 1.0 MW usually require a third party to verify. Generation dispatched and settled by a balancing authority is accepted as independent verification. Generation not reported by a balancing authority may be reported by the interconnected utility or an approved third party, i.e., a QRE. Some tracking systems also support self-reporting for small generators.

Meter requirements

Tracking systems generally require a "revenue-grade meter" for measuring generation, but some are more specific about defining the standard that must be met than others. Operating procedures mention an MV-90 system, pulse accumulator readings collected by the control area's energy management system, or ANSI C-12 standard or its equivalent. The differences are not obvious and may not be significant, but this is a potential topic for discussion and harmonization so that all generators in similar situations are treated equally.

Data validity checks of dynamic generation data

Most tracking systems (MIRECS, M-RETS, NAR, NC-RETS, NYGATS, PJM, and WREGIS) conduct automatic validity checks of electricity production data for all reported generation to ensure that erroneous and technically infeasible data are not accepted. These checks compare reported electricity production to an engineering estimate of maximum potential production using internal algorithms.

Provision for QREs

Most tracking systems provide for QREs to help small generators not reported by balancing authority or utilities to read meters or otherwise check production and facilitate transmittal to the tracking system. By offering this option, tracking systems ensure that generators of all sizes, particularly distributed generation, can receive and transfer certificates.

Self-reporting requirements

All nine tracking systems allow self-reporting for small customer-sited, behind-the-meter generating units. Generation data may be self-reported by the customer or electronically transmitted by a QRE. For example, in WREGIS, a generator with a nameplate capacity (AC rating) of 360 kilowatts (kW) or less is eligible to self-report. It must submit metering records to

substantiate its generation reporting by entering actual cumulative meter readings measured in kilowatt-hours (kWh) or MWh, along with the dates of those readings, via a self-reporting interface. A self-reporting generator owner must abide by the tracking system's requirements when reporting generation data, and all self-reported data submissions are subject to the same quality and auditing standards as generation data reported by a QRE. A self-reporting entity is typically required to have a revenue-grade meter that meets ANSI standards (e.g., C-12) or another industry-accepted, auditable, accurate system for metering, control, and verification. Depending on the tracking system, actual cumulative meter readings must be entered monthly, quarterly, or (at a minimum) annually. Self-reported data are typically validated against expected output using an algorithm based on capacity and capacity factor.

1.5.4 Tracking characteristics for generators and generation attributes

Type of generation tracked

As discussed above, three of the nine tracking systems are "all-generation" systems that track generation from all resource types, not just renewable generation. The other six are for renewable generation only, but how renewable generation is defined is determined by how state RPS programs define renewable or clean energy. Some states, for example, define the incineration of municipal solid waste as renewable under their RPS policies, even though this practice generates anthropogenic emissions from non-renewable feedstocks in the mixed solid waste stream.

Multi-fuel generators

Multi-fuel generators can be registered in many tracking systems, and most systems provide guidance for measurement or calculation of output attributable to each fuel type. These generators are tagged within the tracking system as having a multi-fuel source. Some registries issues independent certificates to each fuel involved in a multi-fuel generator, with those certificates labeled as having come from a multi-fuel source.

Aggregation of small generators

Most tracking systems allow for the aggregation of small distributed renewable energy systems. As noted above, all aggregate registrations come with limitations (e.g., be customer-sited, be within the same state, be associated with the same revenue meter, use the same technology or fuel type, be smaller than a certain size). For example, in NYGATS, a group of small generating units that are not metered together and do not share the same location can be registered by the mutual owner or by a generator agent as an aggregated project under the following conditions: the nameplate capacity of each unit is no more than 200 kW, the aggregated nameplate capacity is no more than 1 MW, the units are in the state of New York, and the units use the same technology/fuel type. All aggregated projects must use a QRE to report generation data.

Emissions data and sources

Several tracking systems have a data field for emissions or emission rates, but since most systems track only renewables, the assumption is that they have zero emissions. The three all-generation tracking systems (PJM-GATS, NEPOOL-GIS, and NY-GATS) include emissions data and

calculate a residual mix, while the others do not.[17] They rely on EPA- or state-agency-reported emissions. Generators lacking continuous emissions monitoring may report emissions from a proxy generator.

Generation unit of measurement

Tracking systems receive data in MWh and issue certificates in MWh (except for NVTRECS, which issues certificates in kWh). Most also roll over any fractional MWh generation and issue certificates to the generator when a full MWh is accumulated in the next issuing period. (ERCOT is the exception: it rounds generation to the nearest whole MWh, with fractions of 0.5 MWh or greater rounded up.) It is also common for tracking systems to allow small generators to accumulate kWh and report when they reach a full MWh. In some cases, they may report generation as infrequently as once a year.

Expiration of certificates

Tracking systems, especially all-generation tracking systems, are generally policy-neutral and simply provide a framework and data requirement needs for compliance and voluntary programs to implement requirements and policies. Consequently, most tracking systems do not have expiration or requirements on the shelf-life of EACs.

[17] Residual mixes are calculated based on the intended end use application of the residual mix. Further examination of existing tracking system methodologies may be required based on the ultimate users intended use.

2. Future needs of tracking system infrastructure

This section discusses emerging trends in energy procurement and energy policies and regulations that may require changing how tracking systems verify electricity generation and track energy attributes. These emerging trends include:

- International corporate GHG accounting standards (e.g., GHG Protocol).
- Corporate reporting.
- Emerging voluntary procurement strategies such as granular matching (i.e., hourly and location-based).
- Low embodied emissions products (e.g., Hydrogen Production Tax Credit, cross-border trade adjustments, environmental product declarations).
- Electricity supplier power source disclosure, including residual mix calculations.

These trends have resulted in an increased interest in a broader set of tracking applications and increased need to validate electricity consumption.

2.1 International corporate GHG accounting standards

In the 1990s, the World Resources Institute and World Business Council for Sustainable Development developed a set of international standards and guidance, referred to broadly as the GHG Protocol. The GHG Protocol is the most widely used standard by organizations seeking to measure their emissions in order to manage them.

The corporate standard guides organizations in how to account for the emissions resulting from activities that occur within their operational boundary or footprint. The standard includes methods for measuring the emissions associated with purchased energy, such as electricity that an organization consumes. Suppliers and consumers of electricity rely on EACs to verify the delivery and consumption of power, providing basic information about the attributes of energy that a consumer uses. The GHG Protocol is used by an estimated 23,000 corporations globally, establishing itself as the most widely used standard of its kind.

In 2024, GHG Protocol administrators began a significant update to its related standards and guidance, including the scope 2 guidance focused on accounting for indirect emissions with purchased electricity use.[18] The GHG Protocol received input from more than 400 stakeholders on the effectiveness and appropriateness of the current scope 2 guidance as well as feedback on areas for updating the guidance. Feedback through this consultative process—including feedback on implementing more granular time and location criteria associated with purchased electricity—indicates more specific scope 2 guidance may be forthcoming. A more granular reporting framework would require more granular data on current market instruments, such as EACs. Furthermore, GHG accounting practices rely on residual mix calculations to avoid double counting. Tracking systems play an important role in providing the necessary data to inform and

[18] Greenhouse Gas Protocol. (2015). *GHG Protocol scope 2 guidance: An amendment to the GHG Protocol corporate standard*. https://ghgprotocol.org/scope-2-guidance

calculate a residual mix, which is used to describe unspecified power or the mix of resources and emissions that consumers receive absent an active procurement of power from a specific resource.

In 2023, voluntary corporate purchases of renewable electricity amounted to an estimated 319 million MWh within the United States.[19] Also as of 2023, voluntary sales of renewable energy accounted for about 48% of the total REC market, compared to 52% used for compliance with state-mandated RPS. (See Figure 4.) S&P Global projects that voluntary demand will exceed compliance demand in 2024 (at the time of this report, this annual data is not yet available).[20] Corporate buyers of carbon-free electricity (CFE) are motivated by GHG accounting standards and guidance around how they purchase, verify, and report their electricity choices and consumption. Market trends in corporate GHG accounting suggest that U.S. tracking system infrastructure may need to evolve to meet the changing needs of corporate accounting standards and practices.

Revisions to the GHG Protocol standards are expected to be finalized by 2026. Based on topline summaries of publicly available comments,[21] the evolution of corporate GHG accounting standards and guidance may necessitate the following enhancements to U.S. tracking system infrastructure. The following list summarizes several capabilities that tracking systems may consider in response to emerging trends in corporate GHG accounting practices.

Considerations for Tracking System Changes Related to Evolving International Corporate GHG Accounting Standards

- Track energy sources and direct or stack emission rates for all generation.
- Record reasons for certificate retirement so corporate reporters can differentiate their voluntary actions from mandated policies.
- Support full disclosure of resource mix and emissions for calculating residual mix to avoid double counting.
- Track hourly and location based matching to consumption, as well as geographic and time specificity for emissions matching, with more granularity.
- Adopt standardized procedures for tracking new and emerging technologies such as energy storage, nuclear power, and carbon capture utilization and storage.
- Support standardized procedures that account for the energy inputs for product manufacturing when evaluating a product's embodied carbon emissions.

Further needs, or revisions to these identified functionalities and capabilities, may be identified as final revisions to the GHG Protocol are released.

[19] National Renewable Energy Laboratory. (2024). *The state of the U.S. voluntary green power market (2023 data)* [Conference presentation]. Renewable Energy Markets Conference. https://www.nrel.gov/analysis/assets/pdfs/status-and-trends-2023-data.pdf

[20] Lenoir, T., & Wilson, A. (2024, February 22). Voluntary renewable energy certificates set to double state targets past 2030. *S&P Global*. https://www.spglobal.com/market-intelligence/en/news-insights/research/voluntary-renewable-energy-certificates-set-to-double-state-targets-past-2030

[21] Greenhouse Gas Protocol. (2024). *Survey on need for GHG Protocol corporate standards and guidance updates*. https://ghgprotocol.org/survey-need-ghg-protocol-corporate-standards-and-guidance-updates

2.2 Corporate reporting

Building off corporate GHG accounting standards and practices, corporations are also increasingly reporting their emissions, either voluntarily or due to regulatory mandate. The drive to report comes about through shareholders and investors requesting a company assesses and reduces its climate risk.

2.2.1 Voluntary GHG emissions reporting

- **Shareholder initiatives.** Corporate shareholder activists are putting pressure on major companies to report their carbon footprints and significant climate risks that could affect their financial performance. Reuters reports that in 2024, shareholders filed 278 climate-related proposals focusing on carbon pollution-reduction goals and strategies for transitioning to a clean energy economy.[22] Only a few proposals are ultimately approved by shareholders, but many are withdrawn in exchange for corporate commitments to take certain actions.
- **CDP.** The Carbon Disclosure Project was founded in 2000, to encourage and assist companies in disclosing their GHG emissions. It has since broadened the scope of environmental disclosure and expanded its outreach to support cities, states, and regions. Over 23,000 companies, representing more than half of global market value, currently report to CDP.[23] CDP says that over 8,000 companies have committed to net zero initiatives, and 96% of the world's top 250 companies report on sustainability.
- **The Climate Registry (TCR).** TCR, started in California in 2007, helps organizations in all sectors reduce their carbon footprint. It has since broadened its focus to all of North America. Currently, about 320 organizations report and verify GHG emissions inventories through TCR.[24]

2.2.2 Mandatory corporate climate risk disclosures

- **Federal requirements.** On March 28, 2024, the Securities and Exchange Commission (SEC) adopted final rules requiring certain companies to disclose climate-related risks:[25]

  > "The final rules require disclosure of Scope 1 and/or Scope 2 greenhouse gas (GHG) emissions on a phased-in basis by certain larger registrants when those emissions are material; the filing of an attestation report covering the required disclosure of

[22] Spalding, K. S. (2024, July 15). Comment: Why climate-related shareholder resolutions are vital for markets. *Reuters*. https://www.reuters.com/sustainability/sustainable-finance-reporting/comment-why-esg-shareholder-resolutions-are-vital-strong-financial-markets-2024-07-15/

[23] CDP. (2024, June 19). *1.5°C still the goal: Businesses disclosing climate transition plans jumps nearly 50%* [Press release]. https://www.cdp.net/en/articles/media/15c-still-the-goal-businesses-disclosing-climate-transition-plans-jumps-nearly-50

[24] The Climate Registry. (n.d.). *About*. https://theclimateregistry.org/about/

[25] The Enhancement and Standardization of Climate-Related Disclosures for Investors, 89 F.R. 21668 (proposed March 28, 2024) (to be codified in 17 C.F.R. §§ 210, 229, 230, 232, 239, and 249). https://www.federalregister.gov/documents/2024/03/28/2024-05137/the-enhancement-and-standardization-of-climate-related-disclosures-for-investors

such registrants' Scope 1 and/or Scope 2 emissions, also on a phased-in basis; and disclosure of the financial statement effects of severe weather events and other natural conditions including, for example, costs and losses."[26]

Affected companies must calculate both scope 1 and scope 2 emissions, provide calculation methods, and disclose their use of carbon offsets and RECs. Although the final rules do not specify the GHG Protocol as the accounting standard, it seems likely that the revised GHG Protocol will influence how companies choose to report.

The final rules have been challenged in court and the SEC delayed the final rules of April 12, 2024, pending the completion of judicial review in the Eighth Circuit.[27]

- **State requirements.** Regardless of the court ruling on the SEC rules, state laws are likely to result in similar outcomes. California has adopted two climate disclosure laws requiring businesses to report their GHG emissions and climate-related financial risks:
  - Senate Bill 253, the Climate Corporate Data Accountability Act, requires companies with annual revenues over $1 billion to disclose their GHG emissions (scopes 1, 2, and 3) to the state in accordance with the GHG Protocol Corporate Standard. The first disclosures are required in 2026 for 2025 data. Companies must also pay an annual fee and get third-party assurance of their reports.[28]
  - Senate Bill 261, the Climate-Related Financial Risk Act, requires companies with annual revenues over $500 million to disclose climate-related financial risks and their mitigation strategies to the public every two years.[29]

  Unlike the SEC rules, these state laws extend to private companies based on revenue thresholds, not just to publicly traded companies. The California Air Resources Board is responsible for issuing implementing rules for these laws.
- **European Union (EU) requirements.** The EU's Corporate Sustainability Reporting Directive entered into force in early 2023 and will affect multinational companies doing business in the EU.[30] Beginning with the 2024 financial year (for reports published in 2025), large companies operating within the EU are required to disclose information

[26] U.S. Securities and Exchange Commission. (2024). *Fact sheet: The enhancement and standardization of climate-related disclosures: Final Rules.* https://www.sec.gov/files/33-11275-fact-sheet.pdf

[27] The Enhancement and Standardization of Climate-Related Disclosures for Investors, 89 F.R. 21668 (proposed March 28, 2024) (to be codified in 17 C.F.R. §§ 210, 229, 230, 232, 239, and 249). https://www.federalregister.gov/documents/2024/03/28/2024-05137/the-enhancement-and-standardization-of-climate-related-disclosures-for-investors

[28] Persefoni. (2024, September 11). California SB 253 and SB 261: What businesses need to know. *Insights*. https://www.persefoni.com/blog/california-sb253-sb261. https://www.quarles.com/newsroom/publications/californias-new-climate-disclosure-and-ghg-related-claims-laws

[29] Persefoni. (2024, September 11). California SB 253 and SB 261: What businesses need to know. *Insights*. https://www.persefoni.com/blog/california-sb253-sb261.

[30] European Commission. (2024). *Corporate sustainability reporting*. https://finance.ec.europa.eu/capital-markets-union-and-financial-markets/company-reporting-and-auditing/company-reporting/corporate-sustainability-reporting_en

See also EU law: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32022L2464.

regarding their scope 1, 2, and 3 GHG emissions as part of their mandatory sustainability reports. The law applies to both listed and large private companies, with some non-EU companies also required to report if they generate significant revenue within the EU market.

Many companies are facing increasing requirements with respect to reporting emissions and climate risks. Ensuring registries and tracking system infrastructure can support credible claims about electricity consumption and related emissions—direct and indirect—will be critical for accurate emissions accounting. Reporting companies need to get information specific to the LSEs that serve them, including full disclosure about emissions associated with any LSE fossil ownership or purchases. For unspecified purchases made by LSEs (i.e., from the spot market), tracking systems need to report generation and emissions from generators even if the generator is not registered with the tracking system for certificate issuance. This reporting enables a complete disclosure of power resources and an accurate calculation of residual mix. The following list summarizes several capabilities that tracking systems may consider in response to evolving trends in corporate reporting.

Considerations for Tracking System Changes Related to Evolving Corporate Reporting

- Track energy sources and direct or stack emission rates for all generation.
- Record reasons for certificate retirement so that corporate reporters can differentiate their voluntary actions from mandated policies.
- Support full disclosure of resource mix and emissions for each LSE and LSE electricity product.
- Support standardized procedures that account for the energy inputs for product manufacturing when evaluating a product's embodied carbon emissions.
- Streamline the process for verifying that a generator is only registered in a single registry to prevent double issuance.

Additional considerations may be identified as revisions to the GHG Protocol are released.

2.3 Voluntary procurement strategies

2.3.1 Annual matching

In the early years of green power markets, renewable electricity use was measured by the quantity of renewable energy purchased relative to a company's annual electricity use within the same market.[31] Some utilities offered green power products that were a set percentage of electricity from renewable sources. As renewable energy supply increased, corporations stepped up and established targets of using renewable energy purchases to match 100% of their annual electricity use, over and above state RPS requirements. As more companies achieved this goal, some began to differentiate their success by emphasizing their impacts on renewable energy development by sourcing their generation from new projects.

[31] The United States has been defined as a single market for the purposes of GHG accounting. Nevertheless, some buyers may prefer to purchase renewable energy that can be physically delivered to the U.S. subregions where their facilities are located.

It also became apparent, however, that not all companies have access or the ability to purchase from an electricity supplier other than their local utilities. Choice of supplier or a preferred product (e.g., source from a new project) is not an actionable choice in some regions of the market; according to a study by EPA's Green Power Partnership, the only choice is unbundled RECs for an estimated 22% of U.S. nonresidential consumers.[32] Even if choices are available, not all companies have the creditworthiness or purchasing power to enter into long-term contracts, or balance sheets to help finance new projects. Smaller companies can find aggregating with other buyers to be time consuming, requiring significant staff resources and technical expertise that many buyers do not have in-house. Clearly, one size does not fit all. Creating more demand is not enough for some buyers, but it's all that some can do. Purchasing EACs to match annual load is still a necessary and appropriate target for many consumers. For GHG reporting, consumers still need to know the emissions associated with their purchases.

2.3.2 Granular matching

More recently, numerous large energy consumers began pursuing more precise ways to match electricity generation to their own electricity use, both on a temporal and a geographic basis.

- **Temporal granularity**. Because many renewable resources generate power intermittently, their generation may not coincide with the timing of the consumer's actual demand, undermining the consumer's goal of renewable electricity use or net zero emissions claims on a granular level. In some cases, dispatchable sources of generation may fill gaps when CFE cannot be delivered and matched to a consumer's electricity demand. If consumers match their purchase of clean electricity to their own electricity use profile, they can help ensure more credible usage claims and address investment risk as more intermittent resources are added to the grid.[33]

  In terms of hourly generation data, most tracking systems in the United States do not currently issue certificates with hourly information. This information exists with the balancing authorities or RTOs that control and dispatch regional generation but may not be shared with all tracking systems. Most tracking systems do not request it because they have not felt the need for that level of detail. Increasing granularity will require specification and build-out of tracking system capability for systems that do not already offer hourly data.

  Some tracking systems have begun to act on hourly matching. M-RETS began tracking hourly certificates in 2019 and demonstrated the ability to issue and track hourly certificates in January 2021, supporting a Google transaction.[34] PJM Environmental Information Services, the manager of the Generation Attribute Tracking System, announced in February 2023 that it will provide hourly, timestamped certificates for PJM

[32] U.S. Environmental Protection Agency. (2022). *National assessment of consumer access to green power supply: Leadership and impact considerations* (EPA 400-R-22-001). https://www.epa.gov/green-power-markets/leadership-and-access

[33] U.S. Environmental Protection Agency. (2024). *24/7 hourly matching of electricity*. https://www.epa.gov/green-power-markets/247-hourly-matching-electricity

[34] M-RETS. (n.d.). *Solutions: 24/7 hourly tracking*. https://www.mrets.org/hourlydata

generation to those who want them.[35] NEPOOL recently approved work on its NEPOOL-GIS to support issuing and tracking hourly certificates on an opt-in basis.[36] Other tracking systems have also made progress towards offering granular data on certificates.

Some utilities, such as Entergy Arkansas and Nevada Power, have already entered contracts with individual large customers to provide hourly matching services, and Georgia Power and Duke Energy have proposed similar services.[37]

To help develop this hourly matching capability, EnergyTag, a nonprofit promoting net zero electricity carbon accounting, has developed a Granular Certificate Scheme[38] and a Granular Certificate Matching Standard,[39] where "granular certificate" represents both temporal and geographic granularity. This standard provides a methodology that can be used as a guide, or as a starting point for discussion, for tracking systems interested in implementing hourly data tracking. Those who advocate for granular certificates may want to consider the early experience of U.S. tracking systems creating hourly certificates. For example, some tracking systems are adding hourly timestamps to annual certificates rather than issuing individual certificates for every hour.

It is not only the private sector pushing hourly matching. At the federal level, EO 14057 requires federal agencies to "seek to match" electricity use with 50% CFE on an hourly basis by 2030.[40]

It is important to note that providing hourly data is not a practical goal for all tracking applications. There are still important applications, such as state RPS requirements and environmental disclosure of electricity products to consumers, as well as voluntary market participants and users, that will continue to depend on annual certificate data for annual-based accounting.

- **Geographic granularity.** Also referred to as location matching, this means that consumers try to purchase electricity from the same grid region where their facilities are located. Tracking systems could record the location of each generator by latitude and longitude, which are already recorded by generators reporting to EIA. Generators of less than 1.0 MW not reporting to EIA would have to provide this information to the tracking system upon registering. As part of retiring EACs, tracking systems could also support the

[35] PJM-EIS. (2023, February 13). *PJM EIS to produce energy certificates hourly* [Press release]. https://www.pjm-eis.com/-/media/about-pjm/newsroom/2023-releases/20230213-pjm-eis-to-produce-energy-certificates-hourly.ashx

[36] Lamson, J. (2024, September 8). NEPOOL Participants Committee votes to support hourly GIS tracking. *RTO Insider*. https://www.rtoinsider.com/86808-nepool-participants-committee-support-hourly-gis-tracking/

[37] Hausman, N., & Bird, L. (2023). *The state of 24/7 carbon-free energy: Recent progress and what to watch*. World Resources Institute. https://www.wri.org/insights/247-carbon-free-energy-progress

[38] EnergyTag. (2024). *Granular Certificate Scheme Standard: Version 2*. https://energytag.org/wp-content/uploads/2024/12/EnergyTag_Granular-Certificate-Scheme-Standard-V2.pdf

[39] EnergyTag. (2024). *Granular Certificate Matching Standard: Version 1.* https://energytag.org/wp-content/uploads/2024/03/Granular-Certificate-Matching-Standard_V1.pdf

[40] Exec. Order No. 14057. 86 F.R. 70935. https://www.federalregister.gov/documents/2021/12/13/2021-27114/catalyzing-clean-energy-industries-and-jobs-through-federal-sustainability

ability to record the location where the beneficiary or owner of the retired EACs will be claimed to enable consumers to match generation location to their own facility location.

- **Electricity storage.** Because of the intermittent nature of many renewable generation resources, energy storage will play a much bigger role in temporal matching. Balancing authorities are also finding storage increasingly important for grid management and reliability. Absent storage, increasing the concentration of renewables in some regions can result in curtailed energy dispatch, which does not result in any energy, environmental, or economic benefits to the buyers or the grid.

  Recognizing this fact, project developers are investing heavily in battery storage.[41] Lithium-ion battery storage is dominant right now and may remain that way for the foreseeable future, but its current application is in managing short-term variations in electricity supply and demand. Questions remain about long-term seasonal storage, where several technologies are still seeking commercialization.

  In addition to smoothing imbalances between supply and demand—which is critical to adding significantly more intermittent renewables, and hence to decarbonization—storage is also important to enable consumers to match generation to their consumption (e.g., 24/7) and can help achieve high matching rates at lower costs.

  Tracking systems have not totally ignored storage, but it has historically been an afterthought because it does not create any new energy. Tracking systems have been careful not to double count the original generation and the energy released from storage, but with the rapid and significant growth of storage installations, some co-located with generation, some located for general grid support, measurement and tracking of storage deserves more attention.

  EnergyTag has proposed a new approach to tracking storage.[42] Basic to the EnergyTag approach is the idea of time-shifting. Storage devices enable time-shifting because they are charged at one time and discharged at a later time. By tracking the attributes of the electricity used to charge the device, and assigning the attributes to electricity discharged at a different time, tracking systems can better support time-shifting. Because storage enables time-shifting, storage tracking requirements are included as part of a broader granular certificates (time and location) standard. While EnergyTag has proposed a solution for tracking storage, it has not been widely implemented. Further review and amendment may be required to suit the U.S. market.

- **Emissions matching.** Emissions matching is a purchasing strategy in which consumers purchase zero-emissions EACs to match their electricity use, but from regions with the

[41] Colthorpe, A. (2024, April 25). Energy storage market grew faster than ever in 2023, BESS [battery energy storage system] was most invested-in energy tech, according to BNEF, IEA. *Energy Storage News*. https://www.energy-storage.news/energy-storage-market-grew-faster-than-ever-in-2023-bess-was-most-invested-in-energy-tech-according-to-bnef-iea/

[42] EnergyTag. (2024). 1.6.5: Time-shifting of storage input attributes to output. In: *Granular Certificate Scheme Standard: Version 2*. https://energytag.org/wp-content/uploads/2024/12/EnergyTag_Granular-Certificate-Scheme-Standard-V2.pdf

highest carbon emissions to maximize their emissions impacts. Advocates of emissions matching say that choosing generation in locations with high average emissions will minimize carbon emissions faster. A number of corporations, as well as the Clean Energy Buyers Association, support emissions matching as well as hourly/location matching as procurement strategies.

Emissions matching is also championed by the Emissions First Partnership. The Emissions First principles encourage companies to invest in decarbonizing global electricity grids and deploy capital to areas that have not historically benefited from corporate investment in clean energy. They argue that an emissions-based approach ensures all technologies are measured in the same manner: in tons of CO_2 reductions.

Some companies emphasize purchasing from regions with the highest locational marginal emissions (LMEs). One definition of LME follows:

> "LME is a metric that measures tons of carbon emissions displaced by 1 MWh of clean energy injected to the grid at a specific location and a specific point in time. LMEs are calculated at each power system node in a manner similar to the Locational Marginal Prices (LMPs) used to set wholesale electricity market prices. LMEs measure emissions by identifying the marginal generators—the generators that would have been producing energy but for the renewable injection to the grid at that location at that moment."[43]

Tracking marginal emissions would require discussion and consensus among tracking system representatives as to how "marginal" should be defined, particularly in terms of location and time duration, so they can provide a consistent specification to grid operators for emissions data. A consistent specification across tracking systems would also be key for energy buyers as they seek to evaluate the emissions impact of various purchase options.

There should be clear education and safeguards around applying marginal emissions information to energy certificates, as EACs should not be treated as emissions instruments, such as a project offset. While marginal emissions data are suitable for targeting project and investment opportunities, EACs are fundamentally designed to describe the power and source that generated it.

Given the multiple strategies pursued in the market surrounding clean energy investments, registries and tracking system infrastructure need to track and capture data in ways that inform sound business decisions resulting in consumer impact and allow purchasers to assess how well they are meeting the objectives of their energy procurement strategies. The following list summarizes several capabilities that tracking systems may consider in response to emerging trends in voluntary procurement strategies.

[43] Oates, D. L., & Spees, K. (n.d.). *Locational marginal emissions: A force multiplier for the carbon impact of clean energy programs*. https://resurety.com/wp-content/uploads/2022/03/REsurety-Locational-Marginal-Emissions-A-Force-Multiplier-for-the-Carbon-Impact-of-Clean-Energy-Programs.pdf

Considerations for Tracking System Changes Related to Emerging Voluntary Procurement Strategies

- Track energy sources and direct or stack emission rates for all generation.
- Standardize the method of determining marginal emission rates and track marginal emission rates for hourly emissions matching.
- Make it easier to check across all tracking systems for duplicate generator registrations.
- Standardize a generator location data element (e.g., latitude and longitude) so it can be used to associate generators with different geographic eligibility definitions for location matching.
- Issue hourly generation timestamps to annual certificates for temporal matching.
- Track retirements for compliance (by state) and for voluntary purposes to support residual mix calculations, and track voluntary retirements by location of claim/beneficiaries to support location matching.
- Adopt a more precise unit of measurement (watt hour [W hr] or MWh decimals) for shorter intervals.
- Register storage devices and track inputs and outputs for hourly time shifting.
- Standardize how carbon capture, utilization, and storage will be tracked.

2.4 Low embodied emissions products

Looking beyond electricity generation, there is a growing need to track or verify carbon emissions in intermediate and final products. Hydrogen is one such intermediate product and can be used in producing final products. The United States has adopted new laws to encourage hydrogen production, in part based on the embodied carbon emissions associated with hydrogen production.

Environmental product declarations (EPDs) are useful tools to help identify low embodied carbon products, and other federal initiatives are also driving policies in this direction. One example is EPA's Construction Material Opportunities to Reduce Emissions (C-MORE) labeling program focused on heavy construction materials.[44] In a related fashion, international trade policy based on embodied carbon emissions is also becoming a factor in manufacturing competitiveness. The competitiveness of U.S.-made products abroad could be impacted by the companies' ability to assess the emissions associated with the electricity used to manufacture products.

These drivers require accurate and verifiable documentation to inform assessments of the embodied emissions, which account for emissions released in all stages of creating a product. Embodied emissions, as defined in EO 14057, are "the quantity of emissions, accounting for all stages of production including upstream processing and extraction of fuels and feedstocks, emitted to the atmosphere due to the production of a product per unit of such product."[45]

[44] U.S. Environmental Protection Agency. (2024). *C-MORE labeling materials & products*. https://www.epa.gov/greenerproducts/labeling-materials-products

[45] Section 603. In: Exec. Order No. 14057. 86 F.R. 70935. https://www.federalregister.gov/documents/2021/12/13/2021-27114/catalyzing-clean-energy-industries-and-jobs-through-federal-sustainability

2.4.1 Hydrogen production

Hydrogen is an energy carrier. It can be used directly as a versatile fuel, but today it is most used in petroleum refining and fertilizer production.[46] Hydrogen is also being explored for use in steelmaking, where hydrogen may replace coal; in making cement, another carbon-intensive process; and other heavy construction materials.[47]

- The Inflation Reduction Act, passed by Congress and signed into law by President Biden in 2022, creates a new tax credit through Section 13204 of the law that subsidizes the production of clean hydrogen.[48] This tax credit is usually referred to as simply "45V" from its section in the Internal Revenue Code. The size of the 45V credit available to hydrogen producers is based on emissions associated with hydrogen production and is expected to stimulate the construction of electrolyzers that produce hydrogen using electricity by separating water (i.e., H_2O) into its molecular components, hydrogen and oxygen. Electrolysis requires generating large amounts of electricity, which constitutes the principal emissions involved with hydrogen production, hence the interest in determining emissions.[49]

  The Internal Revenue Service issued final rules to implement 45V on January 10, 2025.[50] The final rules describe how to determine life cycle GHG emissions rates resulting from hydrogen production processes, as well as other related issues. The rules are critical to tax credit eligibility, and to understanding the kinds of support required from tracking systems.

  First, the final 45V rules define EACs and state that EACs, including those from renewable sources issued through a registry or accounting system, must be used to validate the emissions of electricity used in hydrogen production and the energy inputs

[46] U.S. Department of Energy. (2017, February 21). *Hydrogen: A clean, flexible energy carrier*. https://www.energy.gov/eere/articles/hydrogen-clean-flexible-energy-carrier

[47] Fuel Cell & Hydrogen Energy Association. (n.d.). *Hydrogen in industrial applications*. https://www.fchea.org/hydrogen-in-industrial-applications

[48] Bergman, A., & Krupnick, A. (2022, August 29). How the Inflation Reduction Act can help hydrogen hubs succeed. *Resources*. https://www.resources.org/common-resources/how-the-inflation-reduction-act-can-help-hydrogen-hubs-succeed/

[49] There is also a 45Q tax credit based on carbon capture, utilization, and storage. This credit will likely be tapped by hydrogen producers relying on a totally different technology, fossil fuel reformation. Both technologies (reformation and electrolysis) are eligible for either 45V or 45Q credits, but not both credits. Resources for the Future offers articles, issue briefs, and blog posts on the topic of hydrogen policy. See for example: Krupnik, A., & Bergman, A. (2022, November 9). *Incentives for clean hydrogen production in the Inflation Reduction Act*. Resources for the Future. https://www.rff.org/publications/reports/incentives-for-clean-hydrogen-production-in-the-inflation-reduction-act/

[50] Credit for Production of Clean Hydrogen and Energy Credit (to be codified in 26 C.F.R. § 1). https://federalregister.gov/d/2024-31513

used by taxpayers (i.e., hydrogen producers) under the 45VH2-GREET model.[51] An eligible EAC must provide the following information, as excerpted from the rules:

> "(A) A description of the facility, including the technology and feedstock used to generate the electricity;
>
> (B) The amount and units of electricity;
>
> (C) The COD [commercial operations date] of the facility that generated the electricity;
>
> (D) For electricity that is generated before January 1, 2030, the calendar year in which such electricity was generated;
>
> (E) For electricity that is generated after December 31, 2029, the date and hour (including time zone, or in UTC) in which such electricity was generated;
>
> (F) Other attributes required by 45VH2-GREET or in the determination of a PER [provisional emissions rate] to accurately determine the emissions associated with such electricity;
>
> (G) For electricity generating sources that use carbon capture equipment, the
>
> placed in service date of such equipment; and
>
> (H) The project identification number or assigned identifier."[52]

A qualified EAC registry or accounting system, as excerpted from the 45V rules, is a tracking system that:

> "(A) Assigns a unique identification number to each EAC tracked by such system;
>
> (B) Enables verification that only one EAC is associated with each unit of electricity;
>
> (C) Verifies that each EAC is claimed and retired only once;
>
> (D) Identifies the owner of each EAC; and
>
> (E) Provides a publicly accessible view (for example, through an application programming interface) of all currently registered generators in the tracking system to prevent the duplicative registration of generators."[53]

Note that the above lists do not represent a comprehensive list of requirements.

For purposes of geographic eligibility, "region" is defined as any one of 13 regions in the continental United States that corresponds to 72 Balancing Authorities listed in Table 1 to Section 1.45V-4(d)(2)(ix) of the final rule. This table is the definitive source for

[51] Greenhouse gases, Regulated Emissions, and Energy use in Technologies (GREET®) is a tool used to assess a range of life cycle energy, emissions, and environmental impacts. See U.S. Department of Energy. (n.d.) *GREET*. https://www.energy.gov/eere/greet

[52] Internal Revenue Code Section 1.45V-4(d)(2)(iii), Eligible EAC. https://public-inspection.federalregister.gov/2024-31513.pdf

[53] Internal Revenue Code Section 1.45V-4(d)(2)(viii), Qualified EAC registry or accounting system.

identifying regions, but the regions are illustrated in Figure 6 below. Alaska, Hawaii, and each U.S. territory will be treated as separate regions.

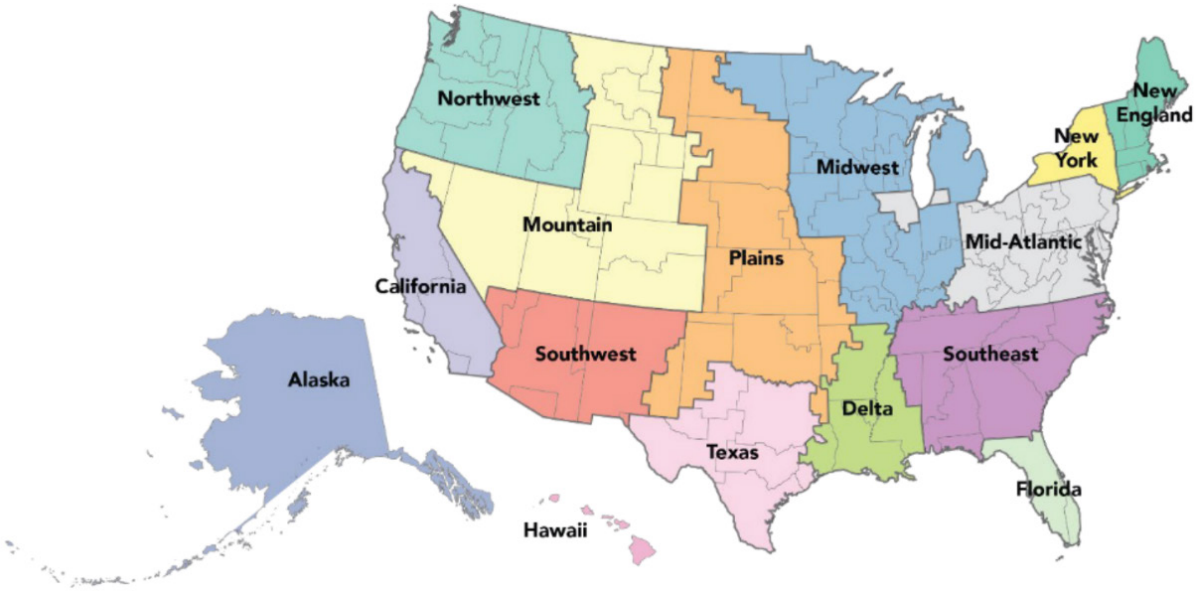

Figure 6. Map of U.S. regions from DOE's National Transmission Needs Study (2023).

The 45V rule specifies that eligible EACs must meet the following requirements, sometimes referred to as the "three pillars." These requirements are paraphrased from the rule to save space. The final rule should be consulted for more details.

- **Incrementality.** The generating facility must have a COD no more than 36 months before the hydrogen production facility was placed in service. If the generating facility uses carbon capture and sequestration (CCS), the CCS technology must have a COD no more than 36 months before the hydrogen production facility was placed in service. An increase in nameplate capacity to an older facility may also be eligible if the uprate occurred no more than 36 months before the hydrogen production facility was placed in service and the incremental electricity is part of the generating facility's uprated production. The rule also provides an opportunity for restarted or decommissioned generating facilities, and existing nuclear facilities (with limits), to qualify under certain conditions.[54]
- **Temporal matching.** EACs used to claim a hydrogen tax credit must be from electricity generated in the same hour that the taxpayer's hydrogen production facility uses electricity to produce hydrogen. Until January 1, 2031, a transition period allows EACs generated in the same calendar year to be considered generated in the same hour that the hydrogen production facility uses electricity to produce hydrogen. Temporal matching may be assisted by electricity storage under certain conditions:[55]

[54] Internal Revenue Code Section 1.45V-4(d)(3)(i), Incrementality.
[55] Internal Revenue Code Section 1.45V-4(d)(3)(ii), Temporal matching.

- The electricity represented by the EAC must be discharged from a storage system in the same hour that the hydrogen production facility uses electricity to produce hydrogen.
- The storage system must be located in the same region as both the hydrogen production facility and the facility generating the stored electricity.
- The volume of electricity use substantiated by each EAC representing stored electricity must account for storage-related efficiency losses.
- EACs from stored electricity must reflect the energy attributes of the electricity generating facility that provided electricity to the storage facility, and reflect the temporal attributes regarding when the electricity is discharged from energy storage.
- The requirement that EACs be claimed and retired only once applies equally to storage EACs.

- **Deliverability.** The 45V rule aims to connect sources of electricity generation to the hydrogen production facility by ensuring that the electricity is actually deliverable to the hydrogen production facility. Both the electricity generator and the hydrogen production facility must be in the same region, and they must be physically connected to a balancing authority (not necessarily the same one) in that region. An interregional delivery of electricity is allowed if it meets certain conditions:[56]
  - The electricity generation represented by the EAC must have transmission rights from the generator location to the region in which the hydrogen production facility is located. That generation must be delivered to (i.e., scheduled and dispatched or settled in) the hydrogen production facility's region.
  - The interregional delivery must be demonstrated on at least an hour-to-hour basis, with no direct counterbalancing reverse transactions, and must be verified with NERC E-tags or the equivalent.
  - The qualified EAC registry or accounting system for each eligible EAC representing delivered electricity must track such delivery.
  - For electricity imported from Canada or Mexico, the electricity generator must provide an attestation to the hydrogen production facility that the use or attributes of the electricity represented by each EAC are not being claimed for any other purpose.

The Hydrogen Production Tax Credit will face similar tracking challenges as hourly matching, given that 45V also requires hourly and location matching. 45V incorporates the requirement of "incrementality" by requiring that the generator powering the electrolyzer be placed in service no more than 36 months before the hydrogen production facility began operation. Tracking systems typically already record the

[56] Internal Revenue Code Section 1.45V-4(d)(3)(iii), Deliverability.

commercial operations date (COD), and have rules for uprating or adding capacity to generators.

- The Infrastructure Investment and Jobs Act of 2021, also called the Bipartisan Infrastructure Law, authorized DOE to spend $8 billion to create at least four "regional clean hydrogen hubs."[57] Clean hydrogen refers to hydrogen produced through electrolysis using renewable or low-carbon emissions energy sources. Clean hydrogen can also refer to hydrogen produced using thermal conversion processes with carbon capture and permanent storage (CCS) technologies that reduce GHG emissions.

  The hubs will be localized centers for the production, transportation, storage, and end use of hydrogen that will help accelerate the large-scale production and use of clean hydrogen. DOE has selected seven regional hubs with the intention of further developing them into a national clean hydrogen network to facilitate the production and use of low-emission hydrogen in sectors of the economy that will be difficult or impossible to electrify.

  The identified hubs in Figure 7 indicate the regions of the country where hydrogen production is likely to occur first, and may require tracking system support to receive available tax credits.

Figure 7. Map of DOE-selected regional clean hydrogen hubs.

2.4.2 Product category rules and EPD for heavy construction materials

Product category rules (PCRs) and EPDs are tools used to assess the environmental impact of construction materials. PCRs define the rules and requirements for creating life cycle assessment (LCA) studies for specific product categories. EPDs summarize the results of LCA studies for specific products or product categories. There are two types of EPDs: (1) industrywide EPDs that provide a general understanding of the typical impact of a product but

[57] See https://www.resources.org/common-resources/a-first-look-at-the-hydrogen-hubs-decisions/ and https://www.energy.gov/oced/regional-clean-hydrogen-hubs-selections-award-negotiations.

cannot be used to compare products, and (2) product-specific EPDs that represent the impacts of a specific product and manufacturer across multiple facilities. It is expected that developing EPDs, through funding from the Inflation Reduction Act, will accelerate embodied carbon emissions data sharing and support federal, state, and local "Buy Clean" initiatives. It will also add momentum to state, regional, and local low embodied carbon building code policies.

PCRs and EPDs are important because they:

- Promote transparency and completeness of LCA studies.
- Lead to consistent practices across industries.
- Make it easier for consumers to compare products by their embodied emissions.

LCA is the thread that connects PCRs and EDPs with two programs that are meant to help the federal government procure construction materials with low embodied carbon. However, note that the role of EAC tracking systems is to track emissions from electricity used in the various stages of production, not to track the entire LCA. The two programs are:

- **Federal Buy Clean Initiative.** An often-overlooked source of GHG emissions is embodied carbon in building and infrastructure construction. The Federal Buy Clean Initiative promotes the use of construction materials with lower embodied emissions in federal procurement and federally funded projects. The Buy Clean recommendations will advance green building materials procurement for federal building and transportation projects and are expected to stimulate private-sector demand for low-carbon versions of concrete, steel, asphalt, and flat glass.

  Inflation Reduction Act funding will enable the General Services Administration to acquire and install low embodied carbon materials and products to use in constructing or altering buildings under its control. Funding can also be used to support capital investments at industrial facilities to decarbonize production of steel, cement, and other hard-to-abate building materials.[58]

  Beyond buildings, the Federal Highway Administration will provide incentives to eligible recipients for using low embodied carbon materials and products in transportation construction projects. This initiative is an important demand-side investment in transportation infrastructure decarbonization, specifically for concrete, asphalt, and steel materials. When leveraged as part of the transportation projects developed through the Infrastructure Investment and Jobs Act, this investment could achieve significant climate impact reductions and further catalyze regional supplies of low-carbon cement and other materials.[59]

[58] Olgyay, V., Tilak, A., & Usry, C. (2022, September 15). New White House "Buy Clean" guidance targets huge emissions hidden in building materials. *RMI*. https://rmi.org/white-house-buy-clean-guidance-targets-emissions-in-building-materials/

[59] Olgyay, V., Tilak, A., & Usry, C. (2022, September 15). New White House "Buy Clean" guidance targets huge emissions hidden in building materials. *RMI*. https://rmi.org/white-house-buy-clean-guidance-targets-emissions-in-building-materials/

- **EPA's Federal Labeling Program.** In support of the Inflation Reduction Act of 2022, which among other things addresses embodied carbon in construction materials, EPA is implementing the C-MORE labeling program. Through C-MORE, EPA and partner agencies are developing strategies to support enhanced standardization, measurement, reporting, and verification of EPDs to drive the market for lower embodied carbon construction materials, with a particular focus on four key materials: concrete, glass, asphalt and steel.60 C-MORE targets these construction materials because of the high GHG emissions associated with their production and the large quantities purchased by the federal government for federal buildings, highways, and infrastructure projects. The C-MORE initiative will provide more impetus to address the challenge of tracking embodied emissions and adds to the focus being brought by cross-border adjustment mechanisms or carbon disclosure policies.

EAC or REC registries increasingly need to support the ability of manufacturers to describe the energy inputs into their manufacturing processes so U.S. manufacturers can maintain their competitiveness, as products will be assessed based on their embodied carbon.

Manufacturers seeking to assess emissions embodied in their products will be required to validate the purchase and ownership of EACs from specified lower emissions electricity sources. The EACs will enable manufacturers to calculate the life cycle emissions associated with the electricity used in producing a product. Manufacturers, however, will be required not just to demonstrate ownership of EACs, but also to show through EAC retirement which facility, manufacturing process, and even product caused the underlying energy attributes to be retired. Essentially, corporations that have purchased EACs at a corporate account level will be required to allocate and document *through the retirement process* where in the manufacturer's footprint an EAC was applied. Verifiers have expressed that having this disclosure on the EAC retirement report will greatly facilitate audits and verification processes.

Tracking embodied emissions is important not only domestically for U.S. industry, manufacturing, and consumers, but also for U.S. jobs and global competitiveness if faced with tariffs based on a product's embodied emissions, as discussed next.

2.4.3 International trade policy

Tariffs may be imposed on critical products imported from countries that subsidize specific manufacturing industries, and consequently whose products may be cheaper than similar products made in the United States. Cross-border adjustment mechanisms are a form of tariff intended to protect the competitiveness of domestic industries under carbon regulation, such as cap and trade, where a competing country may have a cost advantage because its industry is not required to meet an equivalent standard. The EU has already adopted such a law, as described below.

- **Carbon Border Adjustment Mechanism (CBAM).** This law will affect some U.S. exports to the EU; it intends that certain goods imported into the EU must meet the same

[60] See https://www.epa.gov/greenerproducts/cmore.

emissions standards as required by the EU Emission Trading Scheme (ETS), a cap-and-trade program. The products initially affected by the law are in the industrial sectors of aluminum, cement, fertilizers, iron and steel, chemicals (only hydrogen at this time), and electricity. CBAM took partial effect October 1, 2023, and enters into full force January 1, 2026.[61]

Companies exporting these types of products to the EU, called CBAM declarants, must register in the CBAM registry. Their emissions responsibility is based on the average emissions intensity of the exporting country. To the extent their average emissions exceed the EU baseline, they must pay for CBAM certificates at the weekly average price of EU ETS emission allowances.

CBAM declarants may get credit for a carbon price paid in the country of origin, in the form of a carbon tax or emission allowances under a GHG emissions trading system. Further, to the extent that companies can prove they have reduced their emissions in the country of origin, they may reduce their obligation to purchase CBAM certificates by proving lower direct and indirect emissions.[62] The emission factor for electricity must be backed by a power purchase agreement (PPA). Discussion is ongoing regarding whether financial or virtual PPAs (or EAC contracts) will be included in the definition of a PPA.

CBAM and other carbon border adjustments are complex, requiring detailed accounting of emissions (for CBAM, the metric is tonnes of CO_2 equivalent per tonne of goods), and the tracking implications are broad, pertaining to all sources of electricity generation, as well as other inputs.[63]

For companies in the United States, the motivation will be to demonstrate lower emissions from electricity generation used in manufacturing the specified industrial materials and to document the embedded emissions at every stage of production leading up to export to the EU. Tracking systems may play a key role in documenting and verifying the emissions of electricity inputs into the manufacturing process for the specified products.

- **U.S. manufacturer competitiveness.** The EU CBAM policy may stimulate trade policies in the United States to protect domestic manufacturing competitiveness. Several pieces of legislation were proposed in the U.S. Senate in the 118th Congress:

[61] Regulation (EU) 2023/956 of the European Parliament and of the Council of 10 May 2023 establishing a carbon border adjustment mechanism. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32023R0956. This summary is a much simplified version.
[62] The EU law calls these "embedded" emissions, whereas U.S. policy calls them "embodied" emissions.
[63] Kopp, R. J., Rennert, K., & Pizer, W. (2023, October 4). Sailing uncharted waters: International trade becomes an element of climate policy. *Resources*. https://www.resources.org/archives/sailing-uncharted-waters-international-trade-becomes-an-element-of-climate-policy/
Elkerbout, M., Kopp, R. J., & Rennert, K. (2023, December 6). *Comparing the European Union Carbon Border Adjustment Mechanism, the Clean Competition Act, and the Foreign Pollution Fee Act*. Resources for the Future. https://www.rff.org/publications/reports/comparing-the-european-union-carbon-border-adjustment-mechanism-the-clean-competition-act-and-the-foreign-pollution-fee-act/

- The Fair, Affordable, Innovative, and Resilient Transition and Competition Act, or FAIR Act, sponsored by Senator Chris Coons (D-DE).
- The Clean Competition Act (CCA), introduced by Senator Sheldon Whitehouse (D-RI).
- The Foreign Pollution Fee Act, introduced by Senators Bill Cassidy (R-LA), Lindsey Graham (R-SC), and Roger Wicker (R-MS).[64]

These bills were not adopted, but different proposals may be forthcoming in a new Congress. It is worth noting that members of both parties in the Senate recognize the risk to U.S. export industries, and are aware that international tariffs currently have the lead in defining what will be required of imports to the EU. The following list summarizes several capabilities that tracking systems may consider in response to increasing interest in low embodied emissions products.

Considerations for Tracking System Changes Related to Interest in Low Embodied Emissions Products

- Track energy sources and direct or stack emission rates for all generation for carbon disclosure requirements and embodied emissions calculations.
- Streamline the process to determine duplicate generator registrations, which could be done if each system adopted and used a standardized application programming interface (API) framework to provide access to its currently registered generators.
- Enhance retirement purpose data fields to allow consumers to identify the application of the retired EACs, such as for hydrogen production, or for specific facilities or locations.
- Standardize CODs (or placed in service dates) to determine incrementality eligibility, and track generator uprate output separately to qualify that output for hydrogen production tax credits.
- Standardize a generator location data element (e.g., latitude and longitude) so it can be used to associate generators with different geographic eligibility definitions for determining tax credit eligibility and for location based voluntary procurement strategies.
- Issue hourly generation timestamps for temporal matching to help determine eligibility for hydrogen production tax credits.
- Adopt a more precise unit of measurement (W hr or MWh decimals) for shorter intervals.
- Register storage devices and track inputs and outputs for hourly time shifting.
- Track embodied carbon emissions from electricity generation for electricity used in raw material production as well as consumer product manufacturing.
- Standardize how carbon capture, utilization, and storage will be tracked for tax credit eligibility.

[64] For reviews of these bills, see:

- Kopp, R. J., Pizer, W., & Rennert, K. (2023, October 10). *Carbon border adjustments: Design elements, options, and policy decisions*. Resources for the Future. https://www.rff.org/publications/reports/carbon-border-adjustments-design-elements-options-and-policy-decisions/
- Elkerbout, M., Kopp, R. J., & Rennert, K. (2023). *Foreign Pollution Fee Act: Design elements, options, and policy decisions*. Resources for the Future. https://www.rff.org/publications/issue-briefs/foreign-pollution-fee-act-design-elements-options-and-policy-decisions/

2.5 Utilities and other retail electricity suppliers

In some states, LSEs (i.e., retail electricity suppliers) are required to disclose to their customers the generation sources, and related emissions, supplied for consumer use. Even when not required, many corporate consumers across the country report their emissions from electricity use voluntarily, and they need this information from their LSEs. In addition, a few utilities are trying to provide hourly matching supply options, and the federal government has entered into agreements with LSEs to obtain CFE for federal facilities. These efforts are described below.

- **Power source and emissions disclosure**. Nineteen states require utilities and other LSEs to disclose their power sources; some of these states also require associated emissions to be disclosed in consumer labels.[65] Generally, these labels have prescribed information and formats, like nutrition labels for food products, but the method of calculating sources and emissions is not always specified.

  Power source and emissions disclosure is about electricity delivered to consumers. Reporting generation owned by the utility, or generation purchased by the LSE, is not sufficient if that power is resold in the wholesale market. The retail power products should be verified by EACs owned and retired by the LSE on behalf of its consumers, and they should be specific to differentiated products so all customers of the LSE are not reported to be using the attributes of the green power sold only to customers paying for that product. These needs are best supported by all-generation tracking.

  A complete accounting of power sources and emissions requires calculating residual mixes, which consist of "the attributes of unallocated or unclaimed energy delivered to customers on the electricity grid and are a critical tool that prevents the double counting of clean energy and supports accurate calculations of greenhouse gas emissions resulting from electricity use."[66] Essentially, each retail product marketed as renewable energy must be matched with EACs.[67] If there are fewer EACs than MWh sold of that product, the shortfall of MWh not covered (often referred to as "null power") should be assigned the residual mix attributes. A tracking system is uniquely positioned to inform a calculation of the residual mix and assign it, as needed, to each LSE and LSE product.

  Whether or not a state requires power source and emissions disclosure, many corporate consumers need this information to complete their carbon emissions inventories and report to CDP, The Climate Registry, or other target-based programs. The GHG Protocol

[65] Sedano, R. P. (2002). *Electric product disclosure: A status report.* National Council on Competition and the Electric Industry. https://www.raponline.org/wp-content/uploads/2023/09/rap-sedano-electricproductdisclosure-2002-07.pdf

[66] Center for Resource Solutions. (2024). *Guidance for calculating residual mix*. https://resource-solutions.org/document/030624/

[67] According to the Federal Trade Commission's *Guides for the Use of Environmental Marketing Claims*, "A marketer should not make unqualified renewable energy claims…if fossil fuel, or electricity derived from fossil fuel, is used to manufacture any part of the advertised item or is used to power any part of the advertised service, unless the marketer has matched such non-renewable energy use with renewable energy certificates" (https://www.ftc.gov/sites/default/files/attachments/press-releases/ftc-issues-revised-green-guides/greenguides.pdf).

Scope 2 Guidance recommends the following order of preferred sources for the market-based accounting method using emission rates from data sources with the greatest precision:

- Emission rates from EACs purchased and retired on behalf of the consumer.
- Emission rates from generation purchased or contracts (e.g., PPAs) from specified sources.
- Supplier or utility emission rates for products sold to consumers and disclosed publicly.
- Residual mix emission rates.
- Grid average emission rates.[68]

- **Community Choice Aggregations (CCAs)**. CCAs allow local governments to procure power on behalf of their residents, businesses, and municipal accounts from an alternative supplier while still receiving transmission and distribution service from their existing utility provider. CCAs are currently authorized in California, Illinois, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Ohio, Rhode Island, and Virginia. As an example, Peninsula Clean Energy is a CCA serving California's San Mateo County, providing electricity from clean energy sources at lower rates than the incumbent utility. Its current goal is 100% clean energy, and 100% renewable energy by 2030, while maximizing 24/7 energy matching on a time-coincident, hourly basis. See "Granular Matching" above.
- **Utility plans to serve federal government facilities**. At the time of writing, large utility groups are responding to the federal government's interest in transitioning to 100% CFE. In response to EO 14057, the federal government is working with numerous large utilities to fulfill the order's goal of achieving 100% CFE on an annual basis and to match use on an hourly basis to achieve 50% 24/7 carbon pollution-free electricity by fiscal year 2030.[69] Some examples include:
  - Entergy Arkansas and the General Services Administration entered a memorandum of understanding in which Entergy agreed to design and file a CFE tariff by the end of 2022 to help achieve the federal government's sustainability goals in the state of Arkansas.
  - Xcel Energy has entered a similar memorandum of understanding to serve federal facilities in Minnesota, Michigan, North Dakota, South Dakota, and Wisconsin with 100% CFE by 2030.

[68] See p. 48 in Greenhouse Gas Protocol. (2015). *GHG Protocol scope 2 guidance: An amendment to the GHG Protocol corporate standard*. https://ghgprotocol.org/scope-2-guidance
[69] Section 203. In: Exec. Order No. 14057. 86 F.R. 70935. https://www.federalregister.gov/documents/2021/12/13/2021-27114/catalyzing-clean-energy-industries-and-jobs-through-federal-sustainability

- The Southern Company has agreed to develop CFE options for federal facilities in its service territories in Georgia, Alabama, and Mississippi.
- El Paso Electric has agreed to develop CFE tariffs or other offerings for federal facilities in the company's service territory in southern New Mexico and western Texas.
- The federal government issued a request for information in 2024 to serve Mid-Atlantic and Midwestern states, and the General Services Administration and U.S. Department of Defense are seeking utility partners to similarly serve defense facilities.

The following list summarizes several capabilities that tracking systems may consider in response to emerging trends through utilities and retail electricity service suppliers. These capabilities would provide load-serving entities with the ability to track delivery and control of EACs, calculate residual mix for the load they serve, verify hourly matching, and generally keep track of goals achievement.

Considerations for Tracking System Changes Related to Emerging Trends Through Utilities and Other Retail Electricity Suppliers

- Track energy sources and direct or stack emission rates for all generation for accurate carbon emissions disclosure.
- Track certificate retirements for compliance by state, and retirements for voluntary purposes to support residual mix calculations and avoid double counting.
- Support full disclosure of resource mix and emissions for each LSE and LSE electricity product.
- Support calculation of residual mix by each LSE and for each LSE product.
- Make it easier to check across all tracking systems for duplicate generator registrations, which could be done if each system adopted and used a standardized API framework to provide access to its currently registered generators.
- Track greater granularity, such as hourly and location based matching to consumption, and geographic and time specificity for average and marginal emissions matching.

2.6 Definitions, requirements, and procedures considerations

The following list of definitions, requirements, and procedures indicates areas where tracking systems may not show clear consistency in application. The discussion for each item in the list relates to the challenges in equal treatment of generators and generation to be eligible for federal programs. They are identified here as potential issues for discussion by registry operators to determine if differences in language potentially create inconsistent treatment, and whether the language could or should be standardized.

2.6.1 Definitions

- **Generator.** The hydrogen tax credit Section 45V rule requires information about the "generator" because it needs to track emissions associated with electricity used to produce the hydrogen. But it also refers to "generator" as a "generating facility." Registries sometimes use slightly different terminology such as "generating facility,"

"generating project" and "generating unit." The differences in terminology may or may not be significant, but consistent definitions and treatment by tracking systems is important. A potentially useful guide is provided by EIA Form 860 for generator reporting.

- **Commercial operation date.** The COD is the date when a generator first began operation affects eligibility for some state RPS policies; voluntary markets have a recommended 15-year eligibility for generators serving voluntary consumers. To be eligible for hydrogen tax credits, a generator must have commenced operation no more than 36 months before the hydrogen production facility was placed in service. Most registries require a COD, which is usually determined as a date entered by the generator registrant with no apparent verification and no definition. For example. it might be determined by:
  - Start-up
  - Pre-test
  - Operational certification
  - Date of approval to interconnect

  A COD needs a more precise definition to ensure generators in different tracking regions are treated equally.
- **Generator location.** The deliverability requirement for the hydrogen tax credit requires qualifying EACs to represent electricity produced by an electricity generating facility in the same region as the relevant hydrogen production facility. The location of an electricity generation source and the of a hydrogen production facility will be based on the balancing authority to which it is electrically interconnected (not its geographic location), with each balancing authority linked to a single region.[70] A region, according to the 45V definition, "means a Region that corresponds to a Balancing Authority, as identified in the following table."[71] The balancing authority for each generator is reported on Form EIA-860.

  For other programs, such as location matching, the location information currently collected by registries may be:
  - ZIP Codes
  - Latitude or longitude
  - Mailing addresses
  - Physical addresses
  - States

[70] The MISO balancing authority is an exception because it is split into two U.S. regions, as shown in the map located at GREET User Manual as of December 26, 2023. Alaska, Hawaii, and each U.S. territory will be treated as separate regions.
[71] The table referred to is shown in Section 1.45V-4(d)(2)(ix).

- Balancing authorities

To support this program or procurement strategy, it will be important that potential buyers of EACs can consistently identify generator location by their balancing authority and regions, by consulting a tracking system's public list of generators, or via an API. Tracking systems and program managers should discuss whether each certificate should carry this location data point.

- **Repowering or uprates.** Adding capacity to a generation project is often called repowering and sometimes called an uprate. Definitions of both terms offered by EIA refer to any increase in rated nameplate capacity.[72] The incremental capacity may only be eligible for some programs based on the increment's COD. Therefore, the incremental capacity and the COD for that increment are important data points, and the incremental output may have to be metered separately. As part of reviewing this issue, tracking systems should consult Instructions for Form EIA-860, or with EIA staff, to determine a threshold for repowering. A consistent approach may be seen as fair.

2.6.2 Requirements

- **Meter quality.** Tracking systems generally require a "revenue-grade meter" for measuring generation. Operating procedures mention an MV-90 system, pulse accumulator readings collected by the control area's Energy Management System, or ANSI C-12 standard or its equivalent. The differences are not obvious, and perhaps not significant, but it would be a topic for discussion and harmonization so all generators in similar situations are treated equally.
- **Verification.** Most tracking systems support using independent reporting entities that are registered and qualified to report generation data to the tracking system on behalf of generators that are not settled in the control area markets. For quality control reasons, it may be helpful to create a comprehensive or consolidated list across tracking systems of such approved reporting entities, for two reasons:
  - It may make it easier for small generators in need of such independent parties to find one.

[72] The EIA glossary (https://www.eia.gov/tools/glossary/index.php) defines these two terms as follows:
- "**Uprate:** An increase in available electric generating unit power capacity due to a system or equipment modification. An uprate is typically a permanent increase in the capacity of a unit."
- "**Repowering:** For power plants that use combustible fuel, repowering refers to refurbishing a plant by replacing the power-generating technology with a new prime mover and energy source (for example, switching from coal to natural gas). As a result of this replacement, the plant's efficiency usually improves, its emissions decline, or its generation capacity increases. The repowering process usually uses existing facility infrastructure (for example, roads, buildings, interconnection equipment, and fuel and ash storage and handling). For wind farms, repowering refers to replacing existing wind turbines with new, generally larger and higher capacity turbines or with more efficient components. These replacements result in increased nameplate capacity or convert kinetic wind energy into electricity more efficiently. When a wind farm undergoes a full repowering, the existing turbines are replaced with newer turbines and new towers and foundations are often installed. When a wind farm undergoes a partial repowering, the existing towers and foundations are usually retained, while the turbines and other components are replaced."

- A list could be used to record problems that arise with the reporting from such registered entities, identify the types of problems that arise, and identify whether problems tend to occur with some independent reporters more than others.

This information would make it easier to spot patterns and recurring problems that could then be corrected more easily, particularly across tracking systems via an API.

2.6.3 Procedures

- **Generator registration.** The rule for hydrogen production tax credits defines a "qualified EAC registry or accounting system" as one that, among other things, "Provides a publicly accessible view (for example, through an application programming interface) of all currently registered generators in the tracking system to prevent the duplicative registration of such generators."[73] Most of the tracking systems do make public a list of registered generators, but there is no easy way to check for duplicative registrations across tracking systems. A comprehensive list of registered generators, searchable by name and location, could help prevent duplicate registrations. Alternatively, the suggested API could facilitate such checking by the registries themselves and by national program operators doing their due diligence.
- **Generation data communication.** Tracking systems accept different methods of reporting dynamic data, including downloads from balancing authorities, telemetering from individual generators, third-party manual reporting, and in some cases self-reporting. It might be helpful if these approaches could be harmonized so all generators (in their own size class or situation) are treated similarly. Tracking systems generally have safeguards related to third-party reporting and the relationship of the third party to the generator. Generators that self-report generation, typically of small capacity, should be noted as such (either on the generator profile, list of generators, or the EACs issued to the generator owner) since there is a potential conflict of interest.
- **Generation data validity checks.** Most tracking systems use engineering algorithms to check whether reported generation is realistic or likely misreported as greater than what is technically possible. These validity checks usually apply to specific types of generators, typically small or distributed generators. It may be helpful for tracking systems to standardize the types of generators to which this method of error detection applies, as well as to adopt a consistent margin of error that would be accepted or trigger review. The goal of validity checks is to ensure generators are treated equally and generation quantities are equally reliable.
- **Multi-fuel generators.** Some tracking systems enable generators that use multiple fuels to register for certificate issuance subject to an approved methodology for allocating production by fuel type. It is difficult to tell if this allocation formula is unique to each situation, or if it is amenable to a consistent logic, if not formula. It may be helpful if registries jointly review how they enable generators to use multiple fuels and how they might harmonize their approach so emission attributes could be appropriately assigned.

[73] Internal Revenue Code Section 1.45V-4(d)(2)(viii), Qualified EAC registry or accounting system.

In addition, some tracking systems accept *de minimis* amounts of fuel feedstocks when fuel inputs are reported for multi-fuel generators. The threshold that defines *de minimis* may be important to determining eligibility for production tax credits or embodied emissions for CBAM, possibly triggering ineligibility.

- **Interconnection verification.** Some, but not all, tracking systems register and issue certificates to off-grid generators. Because some market participants or program operators prefer to recognize EACs that affect grid operation and emissions, it is important to distinguish between generators that are connected to the grid and those that are not. Furthermore, the hydrogen production tax credit rule requires that the generator and electrolyzer be located in the same region. This requirement means regulators must be able to verify that the generator to which the EACs were issued is interconnected to the same physical grid in which the hydrogen producer consumes electricity. Hence, it must be possible to distinguish EACs from different grid regions. Tracking systems might collaborate to determine if the interconnection location should appear on the certificate, as part of the public list of generators, or should be accessible via an API.

3. Conclusion

Tracking systems play an important role in supporting well-functioning and credible clean energy markets. The nine tracking systems operating in the United States are responsible for issuing and retiring EACs to support credible claims and to track reporting for both compliance and voluntary purposes. As such, they do critical work to account for energy attributes and avoid double counting and double claiming of energy on a shared grid. They establish ownership rights and ensure credibility for the many market participants that trade in EACs.

U.S. tracking systems have been responsive to their stakeholders and are especially strong in supporting the electricity policies and accounting needs of the states that they serve. They also perform an important function in enabling demand for clean electricity within the voluntary market to thrive and grow.

Several new policies and emerging market trends may require that U.S. tracking systems expand their functional capabilities to meet the market's need. New federal tax credits and emerging voluntary procurement practices necessitate the credible tracking of energy attributes to capture a broader set of generating resources and granular generation data on a temporal, locational, and potentially emissions basis. These new demands are driven by market participants, standards-setting organizations, the federal government, and even international legislation. While U.S. tracking systems originated from state regulatory requirements, such as renewable or clean energy portfolio standards and electricity source and environmental disclosure policies, the emergence of a growing voluntary market may require further attention from tracking system operators, who may need engage with stakeholders that have been less of a focus in the past.

The federal government seeks to support consistency, uniformity, and credibility within markets that support U.S. electricity consumers and those that rely on tracking systems. Although the nine tracking systems are similar in many ways, there may be opportunities for collaboration (with each other and with affected stakeholders) to harmonize the details of their evolution and implementation to meet emerging market needs. A collaborative response from tracking systems would serve federal, state, business, and market interests and needs.

Appendix A. Potential key features of a "North Star" energy attribute tracking system

The table below describes a set of characteristics and capabilities that, together, make up a hypothetical tracking system called "North Star." These characteristics and capabilities could serve as a guide as features are added to U.S. tracking systems. They fit into three broad categories:

- Standardizing and enhancing already existing functional capabilities
- Responding to new programs and market needs
- Developing consistency in definitions, requirements, and procedures among tracking systems to support national programs.

"North Star" Tracking System: Characteristic or Capability	"North Star" Features Rationale and Considerations
All-generation tracking	**Expand tracking of energy sources and direct/stack emission rates for all generation.** Some tracking systems already do this, and tracking all generation has become increasingly important for corporate emissions accounting; calculating residual mix; and tracking embodied emissions for EPDs, energy-intensive construction materials, and international trade. Tracking all generation would not require all generators to register with the tracking system, but all generation would need to be reported to the tracking systems by balancing authorities. The GHG Protocol calls for assigning residual mix attributes to load not covered by specified certificates. Three all-generation tracking systems already do this, and the LSEs that use these tracking systems can use the residual mix to provide a complete accounting for each of their electricity products. This practice could be standardized and followed by the other tracking systems. Tracking all emissions is essential to tracking energy storage, which is also key to achieving accurate 24/7 emissions accounting and in emissions matching. Looking ahead, tracking all generation may be increasingly important as CCS enters the commercial market. Emerging applications (corporate accounting, 24/7, 45V, border adjustment mechanisms, EO 14057) are all about emissions, and the whole picture will not be clear unless emitting generation is tracked along with non-emitting generation.
API for generator registration	**Streamline the process for verifying that a generator is registered in a single registry to prevent double issuance of EACs.** Each tracking system provides a public list of registered generators, but there is also a benefit to checking all registries for national programs. An API would make it easier to check across all tracking systems for duplicate generator registrations. It would be beneficial if tracking systems routinely facilitate APIs for generator registration or for account holders. Some users, particularly those pursuing hourly and location matching, are looking for APIs to support data aggregation by location and by hour across tracking systems, and to provide streamlined and third-party access in support of hourly and location matching.

"North Star" Tracking System: Characteristic or Capability	"North Star" Features Rationale and Considerations
Carbon capture and sequestration (CCS)	**Standardize how CCS will be tracked.** CCS is eligible for hydrogen tax credits and will figure increasingly in broader carbon reduction efforts. Tracking systems should work on a consensus proposal about the best way(s) to measure and verify CCS. CCS relates to sections 45Q and 45V of the tax code and tax credits for hydrogen producers using CCS. Eligible hydrogen projects must capture a "qualified carbon oxide," which the statute defines broadly as any CO_2 that is captured by eligible industrial (e.g., ethanol, steel, cement, and chemicals), power (coal, natural gas, and biomass-fired power plants), and direct air capture facilities.
eGRID residual mix	**Support the calculation of a residual mix.** EPA's eGRID produces average emission rates for several levels of geography, and these emission factors are used widely by companies reporting their carbon emissions footprint. As renewable energy claimed by the voluntary market and retired for RPS compliance has grown, however, the overlap between average grid emissions and privately claimed zero emission resources results in increasing double counting. To incorporate a residual mix emission factor into eGRID, EPA needs to know the number of certificates that are retired each year. Most of the information used for eGRID comes from generator reports to EIA, but retired and claimed certificates, in aggregate, are known only to the tracking systems. To calculate residual mix for regions, subregions, states, EPA seeks to work with each tracking system to publish an annual public report showing (1) the number of zero emission certificates issued, by location of generation (state, eGRID subregion, balancing authority); (2) the number of certificates retired for compliance, by state for which the compliance is claimed, by vintage, and by location of generation (state, eGRID subregion, balancing authority); and (3) the number of certificates retired for voluntary claims, by location of generation (state, eGRID subregion, balancing authority), and by location of purchaser/beneficiary (state, eGRID subregion, balancing authority). In addition to an annual public report, it would be desirable to share this aggregated information electronically with EPA directly. For hydrogen 45V, it would improve accuracy and reduce double counting if the regional residual mix were calculated.
Embodied emissions	**Support standardized procedures to document embodied carbon emissions, from initial electricity generation to electricity used in raw material production to electricity used in consumer product manufacture**. EO 14057 establishes a "Buy Clean" Task Force to expand consideration of embodied emissions and pollutants of construction materials in federal procurement and federally funded projects. Embodied emissions also play an important role in U.S. exports to Europe because of the EU CBAM and would undoubtedly play an important role in similar carbon assessments that might be adopted for imports to the United States. Tracking the multiple stages of processing from electricity generation to raw material production to refined consumer product will require some reimagining how certificates are used and tracked.

"North Star" Tracking System: Characteristic or Capability	"North Star" Features Rationale and Considerations
Energy storage	**Adopt standardized procedures for tracking energy storage.** Most tracking systems currently do not issue certificates for storage because the energy used for charging is not known. Tracking systems will need to register storage devices and track inputs and outputs for hourly time-shifting. With the expected tremendous growth of battery storage, a more systematic approach should be adopted. One proposal includes EnergyTag's Granular Certificate Scheme Standard (Section 1.6), which provides the most detailed approach.
Generator	**Consider normalization of terminology across tracking systems.** The hydrogen tax credit (45V) rule requires information about a "generator" because it needs to track emissions associated with electricity used to produce the hydrogen. But it also calls it a "generating facility." Registries sometimes use slightly different terminology, such as "generating facility," "generating project," and "generating unit." The differences may or may not be meaningful, but a useful guide is provided by EIA Form 860 for generator reporting.
Generation data communication	**Harmonize energy generation reporting methods and practices.** Tracking systems accept different methods of reporting dynamic data, including download from balancing authorities, telemetering from individual generators, third-party manual reporting, and in some cases self-reporting. It would be helpful if these approaches could be harmonized so that all generators (in their own size classes or situations) are treated similarly. Tracking systems generally have safeguards related to third-party reporting and the relationship of the third party to the generator. Generators that are self-reported, although typically of small capacity, should be noted as such (either on the generator profile/list of generators or on the EACs issued to the generator owner) since there is a potential conflict of interest.
Generation data validity checks	**Develop and apply consistent methodologies for validating the technical potential of generators to be issued EACs.** Most tracking systems use engineering algorithms to check whether reported generation is realistic or likely misreported as greater than what is technically possible. These validity checks usually apply to specific types of generators, typically small or distributed generators. It would be helpful if tracking systems would standardize the types of generators to which this method of error detection applies and adopt a consistent margin of error that would be accepted or trigger review. The goal is to ensure that generators are treated equally and that the generation quantity is equally reliable.

"North Star" Tracking System: Characteristic or Capability	"North Star" Features Rationale and Considerations
Generator registration	**Provide an API of registered generators to prevent double registration**. The 45V rule for hydrogen production tax credits defines a "qualified EAC registry or accounting system" as one that, among other things, "Provides a publicly accessible view (for example, through an application programming interface) of all currently registered generators in the tracking system to prevent the duplicative registration of such generators."[74] Most of the tracking systems do in fact make available a public list of registered generators, but there is no easy way to check for duplicative registrations across tracking systems. A comprehensive list of registered generators, searchable by name and location, could be important to prevent duplicate registrations. Alternatively, the suggested API could facilitate such checking by the registries themselves and by national program operators doing their due diligence. Feedback is encouraged on a preferred approach and rationale for that approach.
Generator COD	**Standardize the COD (or placed-in-service date).** Tracking systems already record the COD for generators when they register, but definitions of COD may vary and need to be harmonized for federal/national programs. The same data point must be used for uprates or additions to capacity, because the incremental output may meet eligibility criteria for the hydrogen production tax credit based on COD. The date when a generator first began operation affects eligibility for some state RPS policies, and for voluntary markets there is a recommended 15-year eligibility. For eligibility for hydrogen tax credits, a generator must have commenced operation no more than 36 months before the hydrogen production facility was placed in service. Most registries require a COD; for most it is a date entered by the generator registrant, with no apparent verification and no definition. It could include, for example, start-up, pre-test, operational certification, and date of approval to interconnect.
Generator emissions rate	**Apply emissions rate data to certificates.** Several tracking systems have a data field for emission rates, but most track only renewables, and the assumption is that they have no emissions. All-generation tracking systems rely on EPA- or state-agency-reported emissions. Generators lacking continuous emissions monitoring may report emissions from a proxy generator. Recording emission rates will also be important for emitting plants that adopt CCS, and for hydrogen life cycle emissions as required by the 45V rule for tax credit eligibility.

[74] Internal Revenue Code Section 1.45V-4(d)(2)(viii), Qualified EAC registry or accounting system.

"North Star" Tracking System: Characteristic or Capability	"North Star" Features Rationale and Considerations
Generator location	**Standardize a generator location data element so that it can be used to associate generators with different geographic eligibility definitions.** Every tracking system has one or more location data elements. This capability is important to check for double registrations; to associate generators with different definitions of "region," e.g., for tax credit eligibility; and for location matching. Location is essential for understanding what market the generator is in, and a required data element by GHG-P scope 2, location matching, 24/7, 45V, storage and emissions matching. What may be challenging for third parties is that tracking systems collect different levels of location data, from state to balancing authority to North American Electric Reliability Corporation (NERC) region and eGRID subregion. EIA collects physical address and latitude/longitude as well as NERC region and balancing authority for each generator (reported on Form EIA-860). Tracking systems may have these data, but what is available publicly may vary. Location information currently collected by registries may include ZIP code, latitude/longitude, mailing address, physical address, state, and balancing authority. It is desirable that location data be provided with consistency. Potential buyers of EACs need to be able to consistently identify the generator location by its region, by consulting a tracking system's public list of generators, or via an API. Whether this location data point should be carried on each certificate should be discussed by tracking systems and program managers.
Generator resource type (energy source)	**Standardize naming resource type naming conventions.** Identification of resource or fuel type is important because regulatory and voluntary programs have requirements on which types of resource/fuel are eligible for the program. In addition, voluntary green power buyers may have preference for certain resource types. The naming conventions are not standardized, however, and definitions may vary across tracking systems, making it difficult to aggregate fuel types. Further, there is growing interest in expanding fuel types from just renewable to resources based on carbon emissions, and to all generation. It is not clear how easy it would be to map fuel types from one tracking system to another. EIA defines fuel types carefully; if it were necessary to standardize, that would be a good model to consider.

"North Star" Tracking System: Characteristic or Capability	"North Star" Features Rationale and Considerations
Generator size (capacity)	**Standardize method for tracking details related to generator incremental capacity**. This data point is collected because generator capacity may be important for RPS eligibility. Capacity is also used by tracking systems currently as part of a computation to check validity of reported output, particularly for distributed generation. Generator capacity can affect eligibility. For example, the Section 45V rule for hydrogen tax credits requires that generation comes from new incremental capacity relative to when the electrolyzer was built. Whether that generating capacity is entirely new and independently metered, or whether it is incremental relative to existing capacity, there are some variations that tracking systems might need to track. Incremental capacity on an existing generator is problematic because we assume that that incremental output would be evenly distributed across all EACs issued, i.e., the incremental capacity's contribution would be proportionally assigned to all EACs. However, the 45V rule also includes a flat percentage of existing generation to count but could be moderated based on a generator's ability to demonstrate that new eligible incremental capacity was added. It would be helpful to have a tag that allows a program to say generation from this source is eligible because it has had new incremental capacity added within three years of the electrolyzer's COD.
Generator/generation verification	**Support the creation of a comprehensive list across tracking systems of approved third-party reporting entities**. Generators, when they are registered, must provide EIA report documents and may be subject to inspection. Generating units with capacities less than 1.0 MW usually require a third party to verify. Generation dispatched and settled by a balance authority is accepted as independent verification. Generation not reported by balance authority may be reported by the interconnected utility or an approved third party, often called a QRE. Some tracking systems also support self-reporting for very small generators; if so, this is checked against expected output using an algorithm based on capacity and capacity factor. For quality control reasons, it would be helpful to create a comprehensive or consolidated list across tracking systems of such approved reporting entities, for two reasons: (1) it would make it easier for small generators in need of such independent parties to find one and (2) it could be used to record problems that arise with reporting from such registered entities. This information would make it easier to spot patterns and recurring problems that can then be more easily corrected, particularly across tracking systems via an API. The 45V rule for hydrogen requires accreditation of a qualified verifier and CBAM rules require a much more extensive verifier report by accredited verifiers.

"North Star" Tracking System: Characteristic or Capability	"North Star" Features Rationale and Considerations
Hourly generation data	**Track greater temporal and locational granularity**. Matching hourly generation to hourly consumption profiles and matching generator location to location of consumer facilities has become a significant market driver for voluntary markets and has also been incorporated into some federal programs. Two tracking systems offer this option and a third has announced plans to do so, and some large utilities are already working on contracts with the federal government for hourly matching. More granular generation information (at least hourly) is needed for 24/7, 45V, and storage tracking. EnergyTag has a detailed description of a proposed procedure. It should be possible to aggregate or roll up hourly or sub-hourly data to monthly or other time periods. Approaches to providing hourly data vary.
Interconnection disclosure	**Standardize disclosure at registration about the electrical system to which a project is interconnected, or a statement that it is not interconnected.** Some tracking systems issue certificates to "off-grid" generators or to a project that serves a "micro-grid," while others register only projects that are grid-connected. This distinction becomes important when a program or policy considers only grid-connected projects to be eligible (or the opposite, only off-grid projects). To determine eligibility, there is a need for a tag that distinguishes a generator that is grid-interconnected from "off-grid," or a project that serves a "micro-grid." This would require verifiable information upon registration about the electrical system to which a project is interconnected, or a statement that it is not interconnected. In the case of the hydrogen tax credit (45V), the generator must be in the same region as the electrolyzer, and that determination depends on the balancing authority to which the generator is interconnected, so in that case the balancing authority must also be named.
Interconnection verification	**Treat grid interconnection status consistently**. Some, but not all, tracking systems register and issue certificates to off-grid generators. Because some market participants or program operators prefer to recognize EACs that affect grid operation and emissions, it is important to distinguish between generators that are grid-connected, directly connected (off-grid or "islanded generation") and co-located (e.g., with storage or with hydrogen production facilities). Tracking systems should collaborate to determine if the type of interconnection should appear on the certificate, appear as part of the public list of generators, or be accessible via an API.
Location of beneficiary	**Enable location of claim or beneficiary.** Data on the location of use by the consumer/beneficiary would help market observers and federal agencies better understand market demand dynamics. For example, each year NREL publishes a *Status and Trends in the U.S. Voluntary Green Power Market* report, which is hindered by the lack of data on the location of renewable energy consumption. Some residual mix calculations also require as a data point the location of use of claimed certificates. Knowing the location of the consumer/beneficiary is also recommended by the advocates of 24/7 to help match generator location to consumer location.

"North Star" Tracking System: Characteristic or Capability	"North Star" Features Rationale and Considerations
Marginal emissions rate	**Standardize a method for determining and tracking marginal emission rates**. Most emissions data represent direct emissions from power plants and are averaged for the month or year. They end up being used largely for calculating residual mix. But, separately, some consumers seek to maximize their impact by purchasing clean energy from regions with high marginal emissions. This will require agreement about how marginal plants are defined, as well as unit of time and specificity of place for marginal emissions. Operationally, marginal emissions rate (MER) is the emissions from the last generator or generation that is dispatched by a balancing authority to serve load at any point in time. A MER might be for the entire region if it is a single market, or it might be for subregional nodes if the balancing authority operates markets or bidding for different zones. The time interval would have to be noted. In any case, the data would have to be provided by the grid operators to the tracking systems. These data are needed to calculate emission reductions and to match customer hourly use (and emissions responsibility) against hourly MER.
Meter quality	**Harmonize meter quality requirements**. Tracking systems generally require a "revenue-grade meter" for measuring generation, but some are more specific about defining the standard that must be met than others. Operating procedures mention an MV-90 system, pulse accumulator readings collected by the control area's energy management system, or ANSI C-12 standard or its equivalent. The differences are not obvious and may not be significant, but this should be a topic for discussion and harmonization so that all generators in similar situations are treated equally. The 45V hydrogen rule requires revenue-quality meters in some instances and also requires an "industry-appropriate quality assurance and quality control." Hydrogen producers would also need a pipeline interconnection and measurement using a revenue-grade meter. Requiring a revenue-grade meter is not new or unique to these new programmatic or regulatory applications but may be worth considering among tracking systems.
Multi-fuel generators	**Treat multi-fuel generators consistently**. Some tracking systems enable generators that use multiple fuels to register for certificate issuance, subject to an approved methodology for allocating production by fuel type. It is difficult to tell if this allocation formula is unique to each situation or if it is amenable to a consistent logic, if not formula. It would be helpful if registries would be willing to jointly review how they do this and how they might harmonize their approach so that emission attributes are appropriately assigned. In addition, some tracking systems accept *de minimis* amounts of fuel feedstocks when fuel inputs are reported for multi-fuel generators. The threshold that defines *de minimis* may be important to eligibility for production tax credits or embodied emissions for CBAM, possibly triggering ineligibility. We encourage tracking systems to standardize their *de minimis* definitions so that multi-fuel generators are not unintentionally penalized.

"North Star" Tracking System: Characteristic or Capability	"North Star" Features Rationale and Considerations
Production unit of measurement	**Adopt a more precise unit of measurement (W-hr or MWh decimals) for shorter-duration issuance**. Tracking systems receive data in MWh and issue certificates in MWh. Most also carry forward any decimals and issue a certificate when a full MWh is accumulated in the next issuing period. They also allow small generators to accumulate kWh and report it when they have a full MWh or at least once a year. Advocates of 24/7 recommend recording generation in W-hr because they believe it will be necessary if the production interval is reduced to one hour or less.
Program administrator account access	**Provide administrator accounts to administrators of independent programs**. This feature grants access to the tracking system by program administrators of independent programs that seek to layer additional features to certificates, such as environmental certification programs (e.g. Green-e®), or eligibility for other programs. Granting access does not mean they can move certificates. Most tracking systems allow this, but there may be more meanings to this capability than is evident. For example, NAR notes that "program administrators can use a Program Administrator Account. This type of Account is provided to administrators of compliance and voluntary programs that utilize NAR and/or have eligibilities noted for certain Certificates. It will allow Program Administrators to review eligibility and compliance reports. Asset details will only be displayed in a Program Administrator Account if the Account Holder registering that Asset has listed it as eligible according to the specific program/certification." Tracking systems should be prepared to create program administrator accounts for new types of program administrators, such as federal administrators of the hydrogen federal tax credit 45V.
Program/policy application	**Allow for tracking of additional eligibilities as new programs and policies emerge**. Most tracking systems collect the eligibility of generators for voluntary programs and state RPS compliance, and these are often detailed as data elements on the certificate. For example, NC-RETS has certificate fields related to voluntary programs for "Green-e® Energy Eligible" and "LIHI Certified," which are confirmed by the respective program administrators. In the future, additional eligibilities could be included, such as Green-e® Energy Federal Option, 45V, EPA Green Power Partnership, EO 14057, and others. Tracking systems also provide fields indicating the eligibility of a generator for state RPS programs. In many cases, states retain control over certification of RPS eligibility, and they require compliance to be achieved by generators registering in a specific tracking system. For example, California requires the use of WREGIS. Tracking systems should provide a separate data field related to eligibility for each state RPS program.

"North Star" Tracking System: Characteristic or Capability	"North Star" Features Rationale and Considerations
Public reports: aggregated EAC issuance and retirements	**Standardize public reporting frameworks**. All tracking systems provide some public reports, but they are all different and some more difficult to use than others. All-generation tracking systems track non-renewable generation as well as renewable generation, but fossil generator owners generally do not register their generators because there is no value for such EACs and hence are not issued EACs (though their output is reported by the balancing authority to the tracking system and tracked in an administrator's account). They should be able to track anything issued into an account holder's account, and they should be able to track all EACs issued that are defined as renewable or emission-free, and how many are retired (claimed). Such reports should not be difficult to produce but would be more helpful if standardized. Aggregating EAC issuance and retirements by hour rather than quarterly or annually as well as by state and grid region (balancing authority or eGRID subregion) should be considered for future reporting.
Qualified reporting entities (QREs)	**Enhance QRE quality control.** Most tracking systems provide for QREs, independent services registered to report generation data to the system on behalf of generators that are not settled in the control area markets or reported by balancing authorities or utilities. QREs are independent verifiers that read meters or otherwise check production and facilitate data transmittal to the tracking system. Supporting this option ensures that generators of all sizes, particularly distributed generation, can receive and transfer certificates. For quality control, it would be helpful to create a comprehensive or consolidated list across tracking systems of such approved reporting entities. This would make it easier for owners of small generators to find an independent QRE. It could also be used to record problems that arise with the reporting from such registered entities, to identify the types of problems that arise, and to identify whether problems tend to occur with some independent reporters more than others. This information would make it easier to spot patterns and recurring problems that could then be more easily corrected, particularly across tracking systems via an API.

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REC retirement reason/beneficiary data field	**Enable and require reasons for certificate retirement**. Most tracking systems support adding retirement information, but it may be optional. It should be done consistently, including to (1) differentiate between voluntary and compliance retirements (compliance by state); (2) provide greater insight into market development; (3) support residual mix calculations for regions, states, and LSEs; (4) enable the assignment of retired EACs to their specific beneficiaries or consumer facilities, to support location matching; and (5) provide aggregate information by state and tracking region. Some tracking systems also support indicating the beneficiary (the entity the RECs are being retired for). Naming the beneficiary may be important if it is necessary to match a specific consumer to generation within a specific area. The hydrogen 45V rule defines "qualified EAC registry or accounting system" to mean a tracking system that "...identifies the owner of each EAC."[75] Naming the beneficiary in public reports, however, is not necessary for residual mix calculations.
Repowering or uprates	**Standardize approach to repowering and uprates**. Adding capacity to a generation project is often called repowering and sometimes called an uprate. Definitions of both terms offered by EIA refer to an increase in rated nameplate capacity. The incremental capacity may be eligible for some programs based on the increment's COD. Therefore, the increment and the date are critical data points. As part of reviewing this issue, tracking systems should consult with instructions for Form EIA-860, or with EIA staff, to determine a threshold for repowering. A consistent approach would be fair.
Residual mix	**Support calculation of residual mix for full disclosure of resource mix and emissions by LSEs**. Calculating residual mix is an important way to avoid double counting environmental attributes and to assign attributes to electricity whose attributes are unknown ("null power"). Further—because the GHG Protocol prioritizes LSE-level data for corporate accounting of emissions—tracking systems should calculate residual mix for each balancing authority or standardized region to support full disclosure by each LSE and for each of an LSE's differentiated products. Many consumers look to their retail electricity supplier (or LSE) for data about their generation sources and air emissions, but the method LSEs use to create this information is not very transparent. For example, some might just report their owned generation, whether or not it is all used to serve their retail load. Some might have multiple products, but not differentiate among products. Some might exclude null power from their calculations. Tracking systems can support consistency by: (1) calculating residual mix, (2) creating software that makes it easier for LSEs to allocate EACs to each retail electricity product, and (3) assigning the most current residual mix attributes to any MWh in a product that is not matched by an equal number of EACs.

[75] Internal Revenue Code Section 1.45V-4(d)(2)(viii), Qualified EAC registry or accounting system.

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Telemetered vs. manual reporting	**Identify manually reported generation data consistently**. Tracking systems have adequate safeguards related to third-party reporting and the relationship of the third party to the generator. It may be of interest to note when generation is manually reported by the generator owner, since there is a potential conflict of interest. It would also be useful to ensure that tracking systems use consistent methods for capping the total generation potential of a particular project/generator such that misreported generation greater than what is technically possible is avoided.
Universal generator ID	**Adopt a method of assigning a unique ID number to registered generators that is consistent across tracking systems**. Currently each tracking system has its own way of assigning ID numbers and collecting information about the generator's name, location, owner, and designated account holder. To avoid double issuing certificates to a generator that is requesting registration, tracking systems currently must search the list of generators already registered. This works well when they check their own lists of generators, but it is not clear if they also search to see if the generator applicant is already registered in other tracking systems. EIA already assigns unique IDs for generators over 1.0 MW, but the tracking systems nevertheless assign their own IDs rather than use the EIA ID. If they used the EIA ID, that ID could be used to compare data from tracking systems with data collected by Form EIA-860 (latitude/longitude, balancing authority, use of storage, capacity upgrade/downgrade, etc.). This would reduce duplicate effort for generator owners already reporting to EIA.