



Guidehouse
INSIGHTS

White Paper

The Role of Hourly EAC Markets in Facilitating the Clean Energy Transition

Identifying the Value Potential of Future-Proofed Market Design

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Executive Summary

Energy attribute certificates (EACs), which represent the environmental attributes of renewable energy production, enable certificate buyers to make and substantiate clean energy purchasing claims. They simultaneously offer additional revenue streams to renewable energy projects, supporting their bankability and thus contributing to the development of clean energy assets. Several developments have fostered EAC market growth, including standardization, liquidity, and price stability of EACs, with the latter two creating a positive feedback effect as markets accumulate greater levels of trust, transparency, and financing security.

At the same time, with growing skepticism of the impact of existing EAC markets, new tools and approaches are needed to advance the transition to fully decarbonized power grids and improve the credibility of voluntary market claims. Traditional EACs often lack the temporal transparency needed to provide detailed information on important clean energy characteristics, such as the month, season, or hour in which electricity is produced. As more renewable energy is deployed onto the grid, having granular information about clean energy production becomes ever more important.

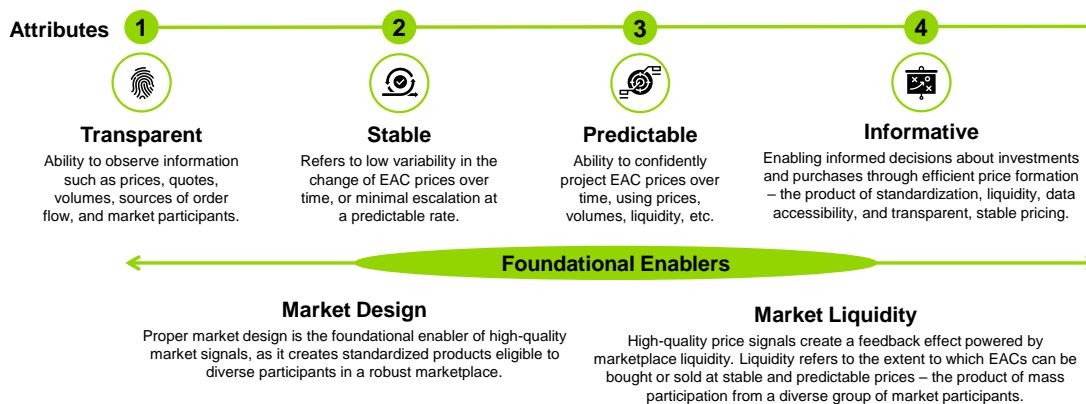
Hourly EACs are an emerging solution to this compounding challenge. These instruments augment the existing EAC market by adding a timestamp that provides information about the exact hour (or sub-hour) in which clean energy is generated. By purchasing and retiring hourly EACs matched against electricity demand on the same grid, these tools can facilitate more accurate market-based carbon accounting under the Greenhouse Gas (GHG) Scope 2 Protocol. Importantly, hourly EACs can also provide differentiated and precise market signals to create incentives for the production of clean energy that is delivered when it is most needed.

For this paper, Guidehouse Insights conducted market research, through interviews and a literature review, to assess the potential role and impact of hourly EACs in accelerating the clean energy transition, as well as important market design principles that enable this. The research uncovered key stakeholder insights on existing market limitations, best-practice design principles, contract structures, pathways for transitioning to hourly EACs, and more. The analysis reveals that appropriate market design is critical to developing a liquid market for hourly certificates that can support additional clean energy development and bankability.

Guidehouse Insights finds that a transition to hourly EAC markets can address transparency, credibility, and price signal concerns; however, the transition should be gradual and work within the parameters of existing EAC marketplaces as much as possible. A smooth transition to an hourly EAC market will require a mix of regulatory- and market-driven responses powered by digital, accessible, and intuitive marketplaces with low participation barriers. Industry stakeholders have made considerable progress over the past few years in data accessibility, standards creation, and the development of enabling technologies to address early-stage adoption barriers.

Based on experiences from today's EAC markets, Guidehouse Insights identifies three features that are key to scaling a successful hourly EAC market: 1) **standardization**, 2) **support for long-term futures trading and exchange-based spot market trading**, and 3) **the provision of high quality price and market signals**. Each of these features can help foster greater bankability and support the deployment of new clean energy projects around the globe.

Figure 1. Key Attributes of High Quality Price and Market Signals



(Source: Guidehouse Insights)

Standardization is a prerequisite for marketplace creation and a catalyzing force for market liquidity. **Standards create a shared understanding between buyers and sellers about the EACs they are trading and ensure EAC integrity, which is key to the credibility of EAC ownership and claims (i.e., no double counting).** The importance of standardization is most aptly demonstrated by the European Energy Certificate Standard (EECS) for Guarantees of Origin (GOs). The EECS standard created trustworthy instruments that enabled customers to purchase clean energy voluntarily, stimulating participation and investment in the industry.¹

A second important feature of EAC markets that enables bankability is the ability for market participants to purchase EACs under **forward markets** as well as on **exchange-based spot markets**. Market participants can forward purchase EACs via long-term bilateral agreements, which allow consumers to hedge against price volatility and developers to secure long-term revenue streams in support of project bankability. Spot markets, where participants can purchase unbundled RECs via exchange-based transactions, act as a critical source of valuation and liquidity for primary transactions (e.g., bundled PPAs).² Additionally, the low barriers to entry of purchasing unbundled EACs relative to more complex procurement mechanisms, like PPAs, offers in-roads for smaller consumers to participate.

High quality price and market signals are a third key feature of EAC markets that support project bankability. These signals are simultaneously transparent, stable, predictable, and informative. The provision of high quality price signals is the product of sustained market liquidity, which in turn is a function of proper market design. Proper market design maximizes efficiency, minimizes complexity, uses clear and consistent language, and ensures transparency and fairness to increase participation.

Traditional EACs have been successful in kickstarting the clean energy transition. As the market has evolved, however, many stakeholders have highlighted the need for future-proofed alternatives that can support deeper electricity system transformation. With thoughtful market design, unbundled hourly EAC markets can address these constraints by creating a critical source of valuation and liquidity that support greater clean energy project bankability.

¹ "Standards for trading energy attributes," *RECs Energy Certificate Association*, Accessed on August 14, 2023.

² Secondary markets refer to exchange-based transactions in over-the-counter (OTC) markets as spot, forward, futures and options contracts.

Acronym and Abbreviation List

CFE	Carbon-Free Energy
EAC	Energy Attribute Certificate
EECS.....	European Energy Certificate Standard
ESG.....	Environmental, Social, and Governance
EU	European Union
GC.....	Granular Certificate
GHG	Greenhouse Gas
GHGP.....	Greenhouse Gas Protocol
GO.....	Guarantee of Origin
I-REC.....	International Renewable Energy Certificate
LFESS	Linux Foundation Energy Standards and Specifications
MWh.....	Megawatt-Hour
NGO	Non-Governmental Organization
PPA	Power Purchase Agreement
REC.....	Renewable Energy Certificate
RPS	Renewable Portfolio Standard
SME.....	Small and Medium Sized Enterprises
SREC	Solar Renewable Energy Credit
SuSI.....	Successor Solar Incentive Program
T-EAC.....	Time-Based Energy Attribute Certificate
US	United States

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Introduction

Traditional EACs serve as the foundation for voluntary markets that enable stakeholders to make clean energy usage and carbon reduction claims. They simultaneously contribute to clean energy development around the globe by facilitating higher returns for project owners and investors.^{3,4} However, as the cost of clean energy has declined and its deployment increased significantly in many markets, EACs' role as drivers of clean energy deployment is increasingly questioned. The current EACs are widely considered as not fit-for-purpose to drive an optimal path for grid decarbonization because they often fail to provide information needed to match clean energy supply and demand at a granular temporal and spatial basis. For this reason, they cannot provide signals that value clean energy based on where and when it is needed most.

Hourly EACs, also known as granular certificates (GCs) or time-based EACs (T-EACs), help resolve the dilemma of time and space. If adopted at large scale, they could deliver the transparent, stable, predictable, and informative price signals that underpin successful markets. The future of hourly EACs will ultimately lie in stakeholders' ability to establish and sustain a vibrant marketplace enriched by an array of buyers and sellers.

This report examines the motivations and mechanisms behind the potential design of an hourly EAC marketplace, and is informed by primary interviews with prominent stakeholders⁵ in today's voluntary clean energy markets, as well as an extensive review of publicly available literature. It discusses:

- The role of current unbundled EAC products and markets in facilitating clean energy financing, deployment, and bankability
- How the combination of accelerating clean energy capacities and declining clean energy costs are testing the upper limits of existing market efficacy
- What proper market design might entail in the transition to unbundled hourly EACs, including market principles, contract structures, and enabling technologies
- How unbundled hourly EACs can help facilitate improved outcomes in clean energy project financing and bankability

Evolution of EACs

An EAC is a tradable instrument representing one MWh of energy produced and generated by a renewable energy source. When renewable energy is generated, it creates two products: electricity and the environmental benefits associated with the production of that energy, known as EACs. Traditional EACs operate on an annual basis, and offer limited information about the specific time, location, or technology used to generate the associated renewable energy.

In North America, EACs are known as renewable energy certificates (RECs); in Europe, they are known as Guarantees of Origin (GOs), and in some countries outside of North America and Europe, they are known as international RECs (I-RECs). These certificates are used by a range of organizations, including

³ "Reimagining REC Markets: Integrating Additionality and Emissionality into a New Carbon-Free Paradigm," *Sol Systems*, November 3, 2022.

⁴ "Skyrocketing EU green certificates could be 'significant' renewables revenue," *S&P Global*, March 2, 2023.

⁵ Informed by 12 interviews with developers, economists, academics, commodity traders & brokers, auditors & certifiers, investors & lenders, energy companies, and non-governmental organizations (NGOs). See Scope of Study for more details on the research methodology.

utilities, businesses, and governments to either comply with states' Renewable Portfolio Standards (RPS) or satisfy voluntary environmental, social, and governance (ESG)-oriented commitments, such as reducing GHG emissions associated with electricity use.

EACs are primarily packaged and sold today in two categories:

- **Bundled** EACs are certificates that are sold with the physical electricity that produce the EACs.⁶
- **Unbundled** EACs are certificates that represent only the environmental attributes associated with renewable energy generation and are sold separately from physical electricity.

The emergence of unbundled EACs can be traced to the deregulation of the U.S. national electricity market in the 1990s. Prior to deregulation, utilities owned both the generation and distribution assets of the electricity system, so consumers had difficulty choosing where their electricity came from. With deregulation, the electricity market opened for competition, allowing more customers to choose their electricity supplier. This enabled renewable energy developers to sell their electricity to the grid, and EACs under separate transactions, thus creating the unbundled EAC.

Different methods of procuring renewable energy carry associated risks and levels of complexity. Because of the simplicity, availability, and price of unbundled EACs, they make up around half of all voluntary green purchases.⁷ The complexity of incorporating power purchase agreements (PPAs)⁸ into corporate energy strategies often excludes many small and medium sized enterprises (SMEs) from viably participating. This is because executing PPAs usually requires credit worthy counterparties, energy forecasting and risk management expertise, contract negotiation expertise, and managing increased reporting and accounting complexities.^{9 10}

Table 1. Benefits and Tradeoffs by Procurement Approach¹¹

	Unbundled RECs	Green Power Programs (Utility)	PPAs
Cost	Low	High	Medium <i>*Economical</i>
Risk	Low <i>*No Upside</i>	Low	Medium <i>*Financial Risks</i>
Scale	High	Medium <i>*Based on Availability</i>	Moderate <i>*Minimum Threshold (>10 MW Usually)</i>
Complexity	Low	Medium	High
Impact¹²	Moderate	Moderate	High

(Source: Guidehouse Insights, LevelTen Energy)

Recent studies highlight significant growth in unbundled EACs. In the U.S., unbundled EACs represented 44% of total market sales in 2021, with volumes growing 23% from 2020-2021, mirroring the growth

⁶ Bundled EACs are often sold and purchased as part of power purchase agreements (PPAs). A PPA is an energy procurement contract between a buyer and a seller that can include the quantity of the energy to be delivered, the supply pattern (fixed or peak-trough model; annual baseload or monthly baseload), the type of energy to be delivered, the commercial operation date (COD), the length of the contract, and most importantly, the pricing structure.

⁷ "Voluntary Green Power Procurement," *National Renewable Energy Laboratory*, Accessed on June 28, 2023.

⁸ "Corporate renewable power purchase agreements (PPAs)," *World Business Council for Sustainable Development*, Accessed on October 8, 2023.

⁹ "How can companies adopt PPAs to decarbonize power consumption?" *World Business Council*, Accessed on October 12, 2023.

¹⁰ "SMEs represent 99% of all business in the EU", *European Commission*, Accessed on November 8, 2023.

¹¹ "4 Ways to Get Renewable Energy Certificates: Pros & Cons of Each," *LevelTen Energy*, May 21, 2020.

¹² This is somewhat subjective, but historically, impact has been based on prices and whether new generation is brought online.

trends of previous years.¹³ In the same year, the Center for Resource Solutions reported the number of consumers buying unbundled RECs through its Green-e Certification Program rose by 86% to almost 410,000 customers.¹⁴

Europe has also witnessed an uptick in unbundled EAC sales. EECS-GO transactions have grown 15% year-over-year resulting in more than 600 TWh of voluntary trade.¹⁵ In emerging markets, demand for unbundled instruments is similarly noteworthy; for example, they account for ~52% of the clean energy volumes purchased by RE100 member companies in Asia Pacific.¹⁶

Role of Unbundled EACs on Bankability

EAC systems create additional project revenues through long-term bilateral contracts, typically under a bundled PPA model, as well as via unbundled EAC market sales.

Multiple interviewees for this paper referenced the ongoing debate over the additionality¹⁷ of bundled versus unbundled instruments, and often shared different views. Common perception dictates that unbundled instruments cannot directly contribute to additionality since these certificates are sold by owners of clean energy assets that have already been commissioned.¹⁸ Yet, most of the stakeholders interviewed for this study pushed back against this generalized claim in noting that unbundled EAC revenues often play a key role in clean energy financing assessments.

Figure 2. EAC Considerations in Lender Assessments

Financial lending models consider the value of EACs when assessing clean energy products' forecast revenues and creditworthiness. For example, financial institutions and lenders analyze regional EAC price points, demand profiles, and liquidity when considering offtake agreements. A variety of factors influence these market dynamics, including policy changes, fluctuations in supply and demand, and the wider energy landscape. **Lenders also analyze historical EAC price trends to understand the risks associated with, and potential upside of, unbundled EACs over project lifetimes.**

(Source: Guidehouse Insights)

For the most part, lenders do not care about the distinction, and believe both bundled and unbundled EACs can support project bankability. This thought is not universal in the ESG community, with many stakeholders believing the inherent additionality of bundled instruments makes them superior. This is logical given that these stakeholder personas have different assumed objectives. However, whether purchased through bundled or unbundled transactions, EACs represent the same thing—the environmental attributes of produced clean energy. “Even if EAC revenues aren’t directly needed for a clean energy project to be deployed, they’re still worth something in that they can be used as a starting point when going to investors for financing,” affirmed one *Investor & Lender* stakeholder interviewed for this white paper.

Voluntary markets, in which unbundled instruments account for most transactions, continue to capture

¹³ “Status and Trends in the Voluntary Market (2021 data),” NREL, September 15, 2022.

¹⁴ “2022 Green-e Verification Report,” CRS, Accessed on July 27, 2023.

¹⁵ “Standards for trading energy attributes,” RECs Energy Certificate Association, Accessed on August 14, 2023.

¹⁶ “Driving renewables in a time of change,” RE100 Climate Group, 2023.

¹⁷ Additionality refers to actions such as purchases or procurements that add new clean energy capacity to the grid that would not have otherwise been added.

¹⁸ “Analysis of the Potential for Corporate Power Purchasing Agreements for Renewable Energy Production in Denmark,” Danish Energy Agency, 2019.

market share from historically dominant compliance markets.¹⁹ “In the U.S., less than half of new capacity additions are projected to come from RPS compliance in 2023...there’s correlational evidence to support the idea that voluntary EAC markets, and in particular unbundled REC markets, have played a role in the dramatic rise in clean energy capacity,” noted an *Auditor & Certifier* stakeholder. “We have seen the real and demonstrable impact that unbundled EAC demand has had on project financing decisions...it is interesting to consider what would happen to the investment landscape if that market were to disappear.” To illustrate this ground truth, another *Investor & Lender* interviewee pointed to ongoing price escalation in non-compliance markets such as Texas, where voluntary buyers have driven up the price of long-term REC contracts from less than \$1 to around \$3 to \$5 today.

While the additionality debate carries on, the present analysis focuses on identifying helpful features of existing EAC markets that support project financing and bankability. As indicated in the excerpt above, the concepts of financeability and bankability are more mutually inclusive than exclusive, as projects can only achieve bankability upon positive financing outcomes.

This white paper identifies and discusses three key features of existing EAC markets that have enriched these interdependent concepts, and that similarly apply in the transition to hourly EAC frameworks. These features include, but are not limited to, **standardization, support for long-term futures trading and spot market trading, and the provision of high quality pricing and market signals.** The importance of these features to EAC bankability are outlined throughout this section.

Standards form the fundamental building blocks for product and marketplace development by establishing consistent protocols that can be universally understood and adopted.²⁰ **Standardized instruments** are required for transacting in a credible and transparent unbundled market, which itself is critical for a stable and dependable EAC framework.

For investors and lenders, a lack of consistent standards makes it difficult to compare the environmental performance of various products or projects. For example, Europe is unquestionably the largest standardized EAC market in the world. As a result of its GO scheme’s standardization and adoption into European Union (EU) law, traded volumes have increased steadily²¹ alongside growing recognition of their bankability impacts. Norway’s Statkraft AS cites GOs as an “increasing factor” when forecasting revenues, referencing the “growing tendency of banks to require off-take agreements for not only power, but also the GOs in order to grant developers loans for building out renewables.”²²

Another prominent feature of EAC markets that enables bankability is the ability for market participants to purchase EACs under forward contracts as well as on spot market exchanges. The duality of **forward-looking markets** and **exchange-based spot markets** can serve the broad needs of diverse market participants. A forward market offers buyers a simpler arrangement than PPAs, acts as an important hedge against EAC price volatility, and can help developers (particularly in regulated markets) lock in EAC cash flow to increase their project revenues.²³ Meanwhile, spot markets²⁴ deliver valuable pricing information and market signals, as certificate prices are determined by supply-demand conditions rather than through direct negotiations. Without a price signal from the secondary market,²⁵ fairly pricing a

¹⁹ “Voluntary megawatt-hours are expected to account for over 59% of all projected U.S. renewable megawatt-hours in 2023, US renewable energy credit market size to double to \$26 billion by 2030,” *S&P Global*, December 22, 2022.

²⁰ “What are Standards? Why are They Important?” *IEEE*, January 11, 2021.

²¹ “EnergyTag and Granular Energy Certificates: Accelerating the Transition to 24/7 Clean Power,” *EnergyTag*, 2021.

²² “Skyrocketing EU green certificates could be ‘significant’ renewables revenue,” *S&P Global*, March 2, 2023.

²³ “The next era of corporate renewables procurement is here,” *Energy Web Foundation*, April 16, 2020.

²⁴ “The trading of RECs can be done on a spot or forward basis. The spot market involves the buying and selling of RECs generated during the current time period in question, while the forward market entails future delivery. The forward market refers to longer term contracts obliging one party to sell the RECs it generates to another party.” *S&P Global*, November 2022.

²⁵ Secondary markets refer to exchange-based transactions in over-the-counter (OTC) markets as spot, forward, futures and options contracts.

bundled transaction (a PPA) is difficult. One of the primary purposes of EACs is to put a price on environmental attributes, so this value can be incorporated into investment and financing decisions; this is not possible without a secondary market.

High quality price and market signals—those that are transparent, stable, predictable, and informative—are a third key feature of EAC markets that support project bankability. The **provision of high quality signals** helps to foster ongoing participation and sustained liquidity, as consumers, investors, and lenders are more apt to participate if certificate prices promote market credibility and financial security. Illiquid markets, meanwhile, suffer from low quality price signals—uninformative, volatile, opaque, unpredictable—that can deter financial stakeholders from clean energy investments.

Figure 3. Key Market and Stakeholder Terminology

- **Bankability.** *The degree to which a project or proposal has sufficient collateral, future cash flow, and high probability of success, to be acceptable to institutional lenders for financing*
- **Liquidity.** *Sufficient volume in the market (many bids and offers) such that participants can easily enter and exit, and minimize transaction costs*
- **Transparent.** *The extent to which prices and orders are published to all market participants*
- **Stable.** *Small and infrequent price movements, up or down, by product type (e.g. for a given hour and location)*
- **Predictable.** *The ability to model outcomes accurately*
- **Informative.** *Providing useful information to market participants about clean energy needs*

(Source: Guidehouse Insights)

When considering high-quality price signals, there may also be tradeoffs in the various attributes depending on the unbundled EAC framework. For example, long-term forward contracts can facilitate greater price stability and predictability, which in turn decreases investor and lender risk in project financing decisions. These benefits are demonstrated by the New Jersey Solar Incentive program, shown in the case study below.

Case Study: New Jersey's Successor Solar Incentive Program

The State of New Jersey offers an example of how unbundled certificate frameworks can lead to greater project bankability, as its Solar Renewable Energy Credit (SREC) market has strongly demonstrated positive project financing outcomes in selling SRECs and power separately.²⁶

Under the newly unveiled Successor Solar Incentive program (SuSI), one SREC-II is created for every 1,000 kWh of solar energy a solar system produces. SREC-IIs are sold independently from electricity (unbundled RECs), so solar system owners still earn money through their utilities net metering programs. Solar homeowners earn a fixed \$85 per SREC-II they generate for 15 years.²⁷

²⁶ "Aligning Green Power Partners with New Renewable Energy Projects Pilot Project Summary," EPA, Accessed on July 27, 2023.

²⁷ "New Jersey's SuSI solar incentive program explained," *SolarReviews*, 2023.

Figure 4. SuSI ADI Sub-Program Incentives

System type	Size	Incentive value per SREC-II
Residential net-metered	All types and sizes	\$85
Small non-residential net-metered (rooftop, carport, canopy, floating solar)	Projects smaller than 1 MW	\$110
Large non-residential net-metered (rooftop, carport, canopy, floating solar)	1 MW to 5 MW	\$100
Small non-residential net-metered ground mount	Projects smaller than 1 MW	\$90
Non-low-middle income (LMI) community solar	Up to 5 MW	\$70
LMI community solar	Up to 5 MW	\$90
Interim subsection (t) projects	All types and sizes	\$100

(Source: SolarReviews)

The initial SREC program had the potential for solar system owners to earn almost three times as much money; however, SRECs were traded on a market where prices fluctuated based on market conditions. This created no guarantees for system owners on how much money they would earn selling SRECs throughout the lifetime of their systems. The subsequent SuSI program eliminated that risk. Without price fluctuations for SREC-II, owners can more accurately predict how much they will earn throughout the lifetime of their solar systems.

In summary, while the NJ SREC-II program may offer lower fixed prices compared to the market-based SREC system, it provides solar owners with a safer investment. The long-term fixed-price bilateral contracts mitigate risks associated with market volatility, downward price pressures, and regulatory changes. For reference, the SREC Registration Program has contributed more than 88% of New Jersey's installed solar capacity over its short tenure,²⁸ due in part to enhanced attributes of bankability, security, and financial certainty.

While EAC exchanges may lack the same level of stability and certainty, with sufficient liquidity, price signals can still be transparent and informative, and the associated revenues from liquid markets can create meaningful value for relevant stakeholders. According to Sol Systems, voluntary (mostly unbundled) EACs typically account for 10% - 20% of overall project revenues, respectively.²⁹ In Europe, GO prices surged in 2022 on the back of growing demand for renewables. If prices were to remain far above long-term averages, estimates are that EU asset owners could raise enough revenue to secure nearly half of the additional production needed to reach the EU's 2030 climate goals, if they decided to reinvest it in new renewable power projects.³⁰

However, in Europe and elsewhere, recent price spikes—primarily attributed to increased demand for clean energy—may not continue, as the costs for renewables continue to decline and deployment accelerates, leading to an oversupply of EACs relative to voluntary market demand in some geographies. In the U.S., generous federal subsidies established under the Inflation Reduction Act will act as

²⁸ "Solar Market Frequently Asked Questions (FAQs)", *New Jersey Board of Public Utilities*, Accessed on September 29, 2023.

²⁹ "Reimagining REC Markets: Integrating Additionality and Emissionality into a New Carbon-Free Paradigm," *Sol Systems*, November 3, 2022.

³⁰ "Skyrocketing EU green certificates could be 'significant' renewables revenue," *S&P Global*, March 2, 2023.

accelerators to oversupply and detriments to additionality.³¹ This has generated some concern among stakeholders over the viability and future of traditional EAC markets.

Growing Limitations of Outdated EAC Markets

EACs have emerged as a common solution for organizations looking to promote clean energy and combat climate change. However, the lack of transparency, which is due to the lack of granularity associated with traditional EAC instruments, threaten the longevity of the market. Currently, most environmental certificates only allow customers to track their certificates on a monthly or annual basis. This means that purchasers of EACs often have no visibility into when associated clean power is being produced, and the prices for EACs are not tied to the value of that clean power to the electricity system. Further, because of the nature of EACs, consumers find that making accurate claims about the carbon reduction benefits from purchasing them can be challenging.

Renewable energy technologies like wind and solar power are now the cheapest (i.e., levelized cost of energy) electricity technologies in many places around the world, and as such, are being deployed economically in significant quantities. While this is undoubtedly positive news for the climate, in many places the supply of clean power is outstripping voluntary market demand, leading to lower EAC prices.

Europe³² and Brazil³³ offer similar case studies on how regional hydropower production can lead to deflated GO and I-REC prices, respectively. In the U.S., multiple regional markets have also experienced historically low EAC prices due to oversupply in the past, including Texas, New England, and PJM, among others.³⁴ Further, loose constraints on how EACs can be applied to match consumption – across regions and time periods—do not accurately reflect the true market conditions and therefore the value of where and when clean energy is needed. These limitations undermine the credibility of EACs globally as their material contribution to projects being built is increasingly in question.

Hourly EACs Offer a Better Alternative

The limitations of existing EAC systems have led to increasing calls for reform that would see certificate markets evolve to more functionally align with the frameworks found in wholesale electricity and other trading markets. This was echoed by Nord Pool in its recent white paper, “As granular certificates will have similar characteristics as power, we expect derivative and forward markets for granular certificates to be quite similar to those for wholesale power, with similar standard products traded: calendar, quarter, month, baseload, peak load, etc.”³⁵

This section highlights the benefits of hourly EACs and how they could support a faster transition to fully decarbonized electricity systems. These insights are drawn from a collection of diverse voices in the industry that transact in or think about these markets on a regular basis.

A shift to hourly EACs would create diverse benefits for many stakeholders. These include incenting higher-impact clean energy development and decarbonization strategies, providing differentiated price

³¹ Xu, Qingyu, Ricks, Wilson, Manocha, Aneesh, Patankar, Neha, & Jenkins, Jesse D., Working Paper: “System-level Impacts of Voluntary Carbon-free Electricity Procurement Strategies”. *Zenodo*, 2023.

³² “EU: Guarantees of Origin (GO),” *Energiepartnerschaft*, Accessed on September 5, 2023.

³³ “Unclear prices hinder Brazil’s IREC market,” *Argus*, March 20, 2023.

³⁴ “REC markets prepare for rising demand,” *Environmental Finance*, December 17, 2018.

³⁵ “About Time: How Incorporating Timestamped Energy Certificates Into Electricity Markets Could Accelerate the Energy Transition,” *NordPool, Granular Energy, Afry*, 2023.

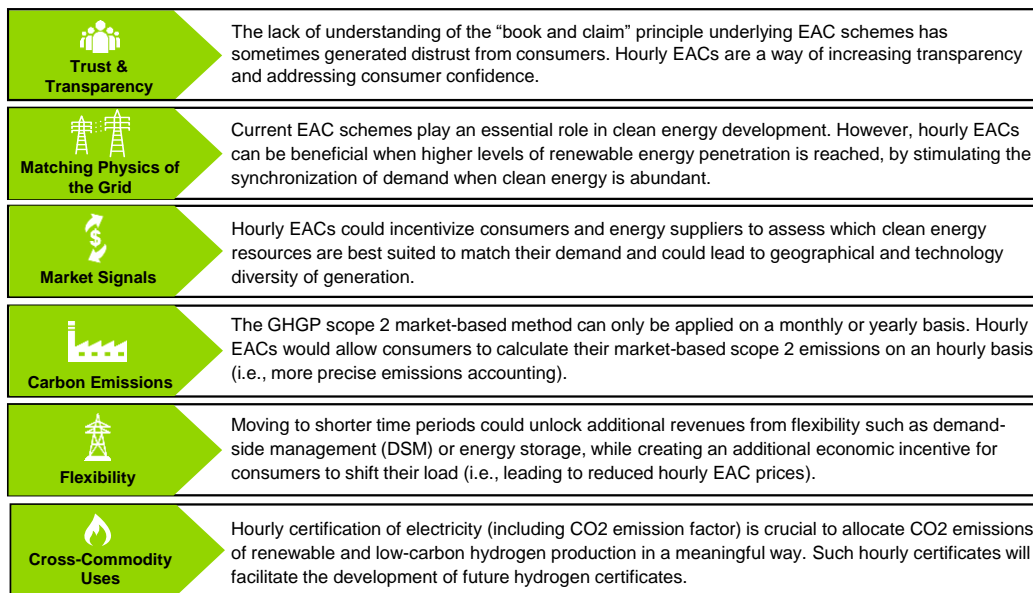
signals, and supporting grid flexibility, among other benefits. Hourly EACs also logically resolve the temporal and spatial credibility concerns associated with claims made using traditional EACs.

The enhanced benefits of transitioning from annual to hourly EACs were espoused by multiple stakeholders, including a *Developer* who highlighted, “The provision of accurate price signals, such that you are building the right resources in alignment with underlying energy consumption, is one of the key benefits of moving to hourly attribute frameworks. By not taking time dimension into account, the limits of annual structures are coming to bear, such as the infamous ‘duck curve.’³⁶ Hourly EAC markets would create a structure that conveys valuable information about when energy is needed and produced, while also encouraging the right type of resources to help bridge this gap.”

The provision of high quality price signals is one of the cornerstone objectives of EAC markets. “The primary role of hourly EACs is to put a price on something that otherwise is not valued. This price discovery component underlies many of the benefit streams being lauded by industry proponents, such as additional project revenues, market signals, tracking and compliance, and increased access to clean energy,” said an *Investor & Lender* interviewee. However, price discovery and effective market signals are blunted as renewable energy capacities scale, leading to oversupply and depressed prices. Hourly EACs remediate these types of temporal dilemmas by creating time- and location-specific price signals in periods of clean energy abundance or scarcity, thus opening up new opportunities for clean power deployment.

Underpinning each of the benefits listed in Figure 5 below is the recognition that hourly EAC markets offer an accelerated path towards complete decarbonization of grids everywhere, and should be valued as such.

Figure 5. EnergyTag: Benefits of Hourly EACs³⁷



(Source: Guidehouse Insights, EnergyTag)

³⁶ Duck Curve refers to the imbalance of peak supply and demand created by the influx of non-dispatchable solar and wind capacities installed in recent years.

³⁷ “EnergyTag and Granular Energy Certificates: Accelerating the Transition to 24/7 Clean Power,” *EnergyTag*, 2021.

Designing Future-Proofed Hourly EAC Markets

The shift to hourly EACs will require broad stakeholder support. While there is widespread agreement that annual EACs will not meet long term needs, there are mixed opinions on when and how this transition should occur. As referenced in previous sections of this white paper, stakeholders increasingly recognize the differentiated value proposition of hourly EACs. Yet, while they are in strong agreement that hourly EAC markets are sound and logical in theory, some caution remains about how quickly a shift to the hourly framework can occur. This caution mainly concerns short-term constraints, such as the disruption to current markets, insufficient participation (market liquidity), and a lack of enabling infrastructure.

Multiple stakeholders expressed a hesitance to moving directly to hourly matching, at least in the short-term. One *Developer* interviewee warned that its counterparts may “see hourly EAC development as potentially undermining the stability and pricing that currently exists.”

“For one, the GO system exists today, and it works,” a *Trader & Broker* stakeholder said. “Moving too quickly towards hourly matching could mix up price signals, and carries the added complexities of algorithm development (similar to what is found in power bidding markets) and coupling certificate markets.”

The advent of widespread voluntary procurement in existing EAC markets demonstrates the readiness and willingness of corporates to participate in secondary markets. But whether these same consumers are willing to pay a premium for hourly EACs to cover more expensive hours in support of marketplace development is not certain. Lastly, some are concerned about the readiness of clean energy supply to support broad participation. According to a *Developer* interviewee, “There simply are not enough clean energy projects, battery installations, etc. to generate during the specific hours in which they’ll be needed.”

In the interest of establishing market liquidity, a more gradual approach could be explored. Guidehouse Insights uncovered a seeming consensus among interviewees that market structures should start broad, and over time, narrow as stakeholders become more comfortable with the concept of hourly matching. For example, markets could begin with narrower location-matching and later move to temporal matching. Improved temporal matching could be achieved through hourly minimum targets that increase over time, or seasonal or monthly certificates that serve as an entryway into more granular approaches.

According to an *Investor & Lender* stakeholder, “The optimal solution lies in the middle ground. You would still have the two ends of the spectrum (monthly/annual and 24/7 RECs), but the broad middle ground is where RECs could be tagged hourly, but not necessarily traded hourly. For example, markets could use daytime and nighttime as trading parameters, or on-peak and off-peak given stakeholders’ existing familiarity with the concept. This type of framework could be a bridge to widespread hourly certificate schemes.”

The EU recently demonstrated how such a glide path could be structured with its Delegated Act on renewable hydrogen production, which mandates that hydrogen production be deliverable³⁸ and temporally correlated, first on a monthly basis, followed by hourly requirements beginning in January 2030. This Delegated Act serves as a positive step toward the development of both the renewable hydrogen and hourly EAC markets in Europe.³⁹

The shift to hourly EAC markets must be done in a way that ensures liquidity and incentivizes new clean energy development via cohesive financing environments. This does not necessarily demand a change in trading mechanisms or market structures. It can be kept simple. According to an *Investors & Lenders* interviewee, “It is not about facilitating full precision (i.e., ‘I want to buy a REC ending in hour 22’), but it is

³⁸ Deliverability is measured using geographical correlation. Specifically, RES producer and electrolyzer shall be located in: the same bidding zone; or interconnected bidding zones, if day ahead market price is equal or higher; or an offshore bidding zone interconnected with the bidding zone where the electrolyzer is.

³⁹ “EU rules for renewable hydrogen,” *European Parliament*, April 2023.

about providing consumers with greater levels of attribute visibility. What this does require is add-on analysis tools to provide the requisite visibility.” And while demand for these types of tools and contract structures is nascent today, we have seen in markets around the world, once regulation or proper market design requires or incents a purchase, products emerge really fast to meet this demand.⁴⁰

The ultimate challenge will be ensuring sufficient liquidity such that certificate prices rise where appropriate. In a theoretical unbundled hourly EAC market, high certificate prices in carbon-intensive grids and intuitive price signals—that is, deflated prices when clean energy production is high—will be early indicators of market efficacy.




Creating Mechanisms to Drive the Widespread Adoption of Hourly EACs

The path to grid decarbonization will require a mix of regulatory- and market-driven responses powered by digital, accessible, and intuitive marketplaces with low participation barriers.

Regulatory Drivers

On the regulatory front, multiple policy changes have been proposed or enacted that could create significant markets for hourly EACs.

Figure 6. Regulatory Initiatives and Market Makers

 24/7 CFE Executive Order	Description President Biden signed an executive order in December 2021 proposing a goal that includes 50% 24/7 carbon pollution-free electricity on a net annual basis by 2030.	Stakeholder Insights “The value of the federal government’s hourly matching initiative as a market pull is big. T-EACs have been pointed to in this conversation.” “There are different ways to flavor compliance obligations outside of RPSs, such as Biden’s EO or Tax Credit 45V.”
 State-Level Movements	Along with state-level RPSs, various REC incentive schemes have led to shining examples of market efficacy. More recently, Colorado announced a new incentive scheme for green hydrogen that includes an hourly matching requirement.	“State-level movements have proven to be extremely impactful.” “U.S. states are also jumping in on the action with their own pledges and initiatives.” “California and New Jersey are prime examples of the impact that EAC markets can have in driving new clean energy generation.” “Consumers are more sophisticated than two years ago, but state-level hourly RECs mandates would still present awareness and education challenges.”
 U.S. Tax Credit 45V	Upcoming U.S. Treasury Department guidance will define implementation standards for the lucrative 45V Hydrogen Production Tax Credit. In a joint letter, a stakeholder coalition proposed a stringent emissions accounting system hinging on hourly-time matching, along with additional and deliverability.	“If we assume the US Treasury comes out with guidance that enforces time- and location-based matching, we’ll see non-PPA products come to market quite quickly.” “The U.S. Treasury’s decision is the entire ballgame. As much as Google and others can contribute, 45V would dwarf these efforts.” “It could be the true market-mover that’s needed.” “If 45V does ultimately require hourly matching and forces the procurement of these attributes, it will be a strong market driver.”

(Source: Guidehouse Insights, Center for Strategic and International Studies⁴¹)

As it stands, there is nothing comprehensive to address hourly EACs from a regulatory perspective. There are, however, proposed policy changes happening across the globe that could act as significant market makers. As required by the EU’s Renewable Energy Directive, two delegated acts on renewable hydrogen were recently approved⁴² and include hourly matching requirements for green hydrogen producers⁴³ starting in 2030. In the U.S., President Biden’s Executive Order 14057 aims to power federal

⁴⁰ “Granular Certificate Projects,” *EnergyTag*, Accessed on June 26, 2023.

⁴¹ “How the 45V Tax Credit Definition Could Make or Break the Clean Hydrogen Economy,” *Center for Strategic & International Studies*, 2023.

⁴² “Renewable hydrogen production: new rules formally adopted,” *European Union*, June 23, 2023.

⁴³ As of January 2030, all renewable hydrogen producers, including those that have signed with existing renewable power generation plants, will need to match the electricity that they have purchased on an hourly basis. Member States who wish to do so can introduce the hourly correlation as of 1 July 2027, subject to notification to the Commission.

facilities with 100% CFE by 2030, including 50% on an hourly basis.⁴⁴ Further, the U.S. Treasury's impending decision on time- and location-matching requirements for eligibility for the 45V Hydrogen Production Tax Credit could serve as a massive catalyzing force; multiple stakeholders referenced this legislation as a theoretical game-changer in the transition to hourly frameworks.⁴⁵

While the majority of policy initiatives aimed at hourly EACs focus on facilitating greater demand, other stakeholders point to green label eligibility requirements as a potential mechanism to reduce oversupply in the long term. "As seen in current EAC markets, oversupply is a major concern as it leads to trivial price signals. One potential resolution is to limit the supply through reducing green label (project online date) eligibility windows from 15 years to 10 years," suggested one *Trader & Broker* interviewee. "While these rules made sense a decade ago, it is false to assume the same subsidy reliance and payback periods still apply today. For example, policymakers are considering tightening eligibility requirements for hydrogen production to just two years."

Yet, while regulatory support will be instrumental in stimulating hourly EAC markets, broad acceptance from a diverse set of voluntary consumers will be required for marketplace vibrancy.

GHG Protocol

EACs are the predominant mechanisms used by companies to make Scope 2 emissions claims when calculating or reporting their carbon footprint. In 2015, the GHG Protocol (GHGP) reinforced the role of EACs in market-based accounting as part of its Scope 2 guidance. Future updates could include hourly EACs as market-based contractual instruments.⁴⁶ Many industry stakeholders have identified hourly EACs as logical instruments to help consumers make credible and verifiable emissions claims.

One of the major topics of debate in drafting future guidance is the role of market- versus location-based accounting. While some proposals would remove all market-based accounting and procurement, the larger pool of stakeholders view this unfavorably. Whether for hourly or annual accounting, every stakeholder should be for markets. Interviewees from *Academia* pushed back against the proposals to remove market-based accounting, emphasizing that "WRI should have market instruments as an option" and "market-based instruments are important because they provide a signal to purchasers to do something different, and enable a lot of impacts that corporates want to have."

Nearly every stakeholder interviewed for this white paper echoed the preference for recognizing unbundled hourly EACs as a legitimate procurement method in addition to traditional EACs. These pointed insights range from "it's pie in the sky thinking that every Scope 2 instrument has to be forward, bundled, and everything will go right" to "without the ability to include unbundled RECs in Scope 2, the whole thing falls apart."

In countries with high renewable energy penetration, the difference in accuracy between yearly and hourly accounting on emissions calculations is already non-negligible. "Transforming the EAC market to be productive in the next decade requires grappling with many substantial "grey areas" and methodological question marks," noted one *NGO* interviewee. "The best options are those which have the most easily quantifiable emissions metrics—this benefits hourly EACs marketplace development." These inaccuracies will only increase as the clean energy transition accelerates and carbon intensity variations

⁴⁴ "100% Carbon Pollution-Free Electricity on a Net Annual Basis by 2030, Including 50% on a 24/7 Basis," *Council on Environmental Quality*, Accessed on August 1, 2023.

⁴⁵ "About Time: How Incorporating Timestamped Energy Certificates Into Electricity Markets Could Accelerate the Energy Transition," *NordPool, Granular Energy, Afry*, 2023.

⁴⁶ "EnergyTag and Granular Energy Certificates: Accelerating the Transition to 24/7 Clean Power," *EnergyTag*, 2021.

become more important. Moving to hourly EACs would be a noteworthy step in empowering consumers while simultaneously paving the way for more temporally precise emissions accounting.⁴⁷

Data and Software Tools

The burden cannot fall solely on the backs of consumers, as not every company in the world will be able to match hourly requirements in the near-term. It is important to provide a menu of options so the market can meet consumers where they are. An EAC market should provide options for companies to move toward greater hourly matching over time and meanwhile, could allow them to make more credible claims. Companies with RE100 goals likely already have some procurement that is matched to their demand at an hourly level, and hourly EACs can be used to track and substantiate this. Hourly 24/7 CFE products for a few large commercial customers might be quite different from a product intended for all potential customers in a utility territory. This was echoed by a *Trader & Broker* interviewee who mentioned, “There are hours of the year that are difficult to cover with renewables, and it is challenging to cover these periods in the volumes that a company may require. This requires developing market products that will enable coverage at scale.”

Several enabling forces must be realized: 1) common data standards to increase the accessibility of high quality energy data; 2) enhanced data management and visualization tools; and 3) hourly registry capabilities that allow for unbundled trading. To this end, industry stakeholders have made considerable progress over the past few years in standards creation, data accessibility, and the development of registry infrastructure.

Enabling consumers to access consumption and market data easily, such as by establishing data standards, is a logical first step to fostering greater adoption of hourly matching schemes. “The topic of standardization is underappreciated,” one *Economist* interviewee contends. “In order to have a market, you need to have standardized commodities. All successful markets need standardization so it is clear what is being traded, and to increase the number of traders.” One of the most important participants in this process is the nonprofit organization EnergyTag. This industry-led initiative is working to define the first standard for hourly (or sub-hourly) energy certificates, and consists of a diverse set of stakeholders throughout the energy industry.⁴⁸

The Linux Foundation Energy Standards and Specifications (LFESS) Carbon Data Specification Consortium, a pre-competitive industry group, is also working to create open-source energy data standards that can improve access to the data needed to enable more accurate carbon accounting.⁴⁹ Once consumers have access to standardized data, the challenge of efficiently managing and analyzing this information remains. Software and analytics tools to verify electricity sources and emissions consumption already exist and are in the initial stages of scaling.⁵⁰

Registries are the entity responsible for issuing, transferring, and retiring EACs—for voluntary and compliance markets—to certify claims and avoid double counting. Current tracking system capabilities in accessing hourly generation data have not yet been fully developed. Most registries are months to years away from having a solution in place, but upon the decision to implement hourly tracking, most would only require one to two years to stand up these capabilities.⁵¹ Some registry providers, including M-RETS (US), PJM GATS (US), Unicorn Systems (Europe), and Evident (international), are in various

⁴⁷ Ibid.

⁴⁸ “EnergyTag and Granular Energy Certificates: Accelerating the Transition to 24/7 Clean Power,” *EnergyTag*, 2021.

⁴⁹ “Carbon Data Specification Consortium,” *GitHub*, Accessed on July 5, 2023.

⁵⁰ “Granular Certificate Projects,” *EnergyTag*, Accessed on June 26, 2023.

⁵¹ “Readiness for Hourly: U.S. Renewable Energy Tracking Systems,” *Center for Resource Solutions*, June 15, 2023.

stages of incorporating granular tracking functionality.⁵²

Bankability of Hourly EAC Markets

What does a theoretical unbundled hourly EAC market look like? What contract structures and mechanisms must be in place to enable a vibrant marketplace, or to facilitate clean energy financing and project bankability? The answers to these questions will depend on which stakeholder is being asked. Yet, every suggestion is likely to revolve around a common cornerstone: market liquidity.

Figure 7. Role of Unbundled EACs on Project Financing and Bankability

Investors rely on tradable unbundled EACs in their underwriting to finance renewable energy projects; the opportunity to sell unbundled EACs eventually is an essential aspect of an owner's initial investment in a new project. Although this may not inherently lead to new clean energy development, **unbundled EAC markets represent a core part of the initial underwriting and financing of projects.**

(Source: Guidehouse Insights)

Many key attributes of unbundled EAC markets—competition, predictability, reliability, robustness, stability, transparency—contribute to market liquidity. “Only a few EAC markets today have any meaningful liquidity, so this is naturally a major concern for hourly EAC marketplace development. The ultimate viability of hourly certificate markets will depend on participation from a deep and wide variety of buyers,” said one *Developer* interviewee. “It’s critically important to have sufficient market liquidity,” echoed another *Economist* stakeholder. While no easy answer exists for the complicated question of liquidity, through proper market design, covered in more detail later in this white paper, stakeholders can conceptualize and realize a vibrant, unbundled hourly EAC market.

The key features of traditional EAC markets outlined in this white paper—standardization, support for long-term futures trading and spot market trading, and the provision of high quality pricing and market signals—are also necessary for a successful hourly EAC market. In defining the transition to hourly EAC markets, market efficacy rests on a similar yet evolved foundation.

Standardization

The role of standards in creating and scaling unbundled EAC markets holds the same significance regardless of temporal context, in order to build stable and reliable markets.

In the case of early-stage, uncertain, or diverse regulatory environments, bankability is particularly vulnerable to lender scrutiny given the elevated financial risks and limited transparency.⁵³ This is why standard initiatives for more granular implementation, such as EnergyTag and the LFESS mentioned earlier, are valuable enablers of marketplace development.⁵⁴ It should be the duty of standards (or labels) programs to add additional marketplace constraints based on their underlying goals and objectives, rather than the marketplace enforcing stringent restrictions on itself so it can best encourage market participation.

⁵² “About Time: How Incorporating Timestamped Energy Certificates Into Electricity Markets Could Accelerate the Energy Transition,” *NordPool, Granular Energy, Afry*, 2023.

⁵³ “RPPA’s financing structures and bankability requirements for RE Projects,” *SAARC Energy Centre*, November 2021.

⁵⁴ “EnergyTag and Granular Energy Certificates: Accelerating the Transition to 24/7 Clean Power,” *EnergyTag*, 2021.

Contract Structures

The goal should be to create products and systems that create vibrancy in marketplace participation. The best way to achieve this is by allowing consumers to purchase unbundled instruments according to their needs.

Longer-term forward markets offer a means for the buyer to hedge price volatility and the seller to gain revenue security, which helps manage risk on both sides. This is particularly important with the uncertainty that comes from a transition to hourly market constructs. However, the existence of a forward market alone is a sign of an immature market⁵⁵ and should not be legislated in replacement of, or at the expense of, open and competitive spot hourly EAC markets.⁵⁶

Figure 8. Case Study: Forward Market in the Airline Industry

*In the airline industry, for example, **strong fluctuations in fuel prices facilitated the creation of a futures market to help deal with price variability** to pass along risk to those better equipped to handle it. **If the price of hourly EACs were to surge in the future**, for example, via federal or state-level hourly matching mandates, **the ability to lock in futures contracts would become especially important**. California experienced this type of price shocks in the 1990s with sulfur dioxide permits.*

(Source: Guidehouse Insights)

Spot market trading enables a wider pool of EAC consumers to provide valuation and liquidity to hourly markets. For renewable resource developers, this translates into more counterparties to purchase EACs.⁵⁷ If long-term bilateral contracts (i.e., bundled PPAs) were the only option, no market mechanism would transparently demonstrate, through an hourly price signal, where and when clean energy is needed most.

“While these instruments carry some additional risk, the projected rise of unbundled hourly RECs reflects the growing sophistication of the marketplace. There is growing awareness of corporate objectives which has led to an expansion in the number of available pathways,” according to one *Developer* interviewee.

Other stakeholders reinforced this point in affirming that unbundled and tradable hourly EACs (i.e., secondary markets) are not only helpful, but necessary to reach the scale and sophistication found in existing EAC markets. As one *Auditor & Certifier* stakeholder stated succinctly, “Unbundled tradable EACs are needed in order to scale hourly EAC frameworks.”

High Quality Price and Market Signals

While price discovery from secondary markets is important for market liquidity and project bankability, if certificate prices are highly unstable or unpredictable, financiers may still opt out of investing in certain clean energy projects. In this context, price signals that minimize financial risk for investors and lenders are transparent, stable, predictable, and informative.

⁵⁵ “Exchange-traded spot and futures contracts and OTC markets are both necessary to ensure a mature, fully functioning market.” *International Swaps and Derivatives Association*, September 2021.

⁵⁶ “Supplemental Guidance Document Best Practice Principles for Renewable Energy Certificate Markets”, *Environmental Markets Association*, Accessed on October 8, 2023.

⁵⁷ *Ibid.*

Figure 9. Role of Hourly EACs in Stimulating Storage, Hydrogen, and Demand Management

Unbundled hourly EACs **create a new market signal for clean energy developers, energy storage, hydrogen, and demand-side management solutions.** In periods of high supply and low pricing, storage owners can buy or store any clean electricity paired with a battery (and its corresponding certificates). Then at a later hour of the day, put the electricity back onto the market, and sell the higher priced certificates. This could also **play an important role in the development of the green fuels sector** as the time and location information contained on the certificates will provide verifiable ways to track the production of green hydrogen.

(Source: Guidehouse Insights)

For clean energy developers, the provision of high quality price signals is hindered by the temporal constraints of annual matching schemes. Hourly EAC markets enable owners to capture the spread between low and high priced hours, creating a much-needed flexibility market signal in support of, for example, energy storage development.⁵⁸ Investors and lenders, meanwhile, desire stable and predictable price signals—the product of market liquidity. To this end, one of the stakeholders from the *Developers* community offered two potential ways to help jump-start liquidity in an early-stage hourly EAC market.

1. *“Help market participants coalesce around a market structure, whether this be a trading platform or solution that is sponsored by existing market operators. This proof-of-concept needs to be robust enough for people to show up, but not so robust that price points cannot be met. The sweet spot lies somewhere in the middle.”*
2. *“Work with state officials to consider or look at an hourly carve out for existing RPSs (e.g., requirement that consumers purchase hourly attributes for a portion of their load). These targets must be aggressive yet achievable. If they are not aggressive enough, prices will be depressed; if it is too aggressive, consumers may just pay the alternative fees. This would require a lot of work on the compliance side, but is a viable option.”*

However, jumpstarting liquidity and sustaining it are not one-in-the-same, as the latter is more a function of proper market design. According to one *Economists* interviewee, “The mapping of characteristics into stable and predictable prices is what becomes clear in proper market design.”

Table 2 offers several best-practice principles to help inform unbundled hourly EAC market design.

⁵⁸ “About Time: How Incorporating Timestamped Energy Certificates Into Electricity Markets Could Accelerate the Energy Transition,” NordPool, *Granular Energy*, Afry, 2023.

Table 2. Exchange Market Design: Best Practices⁵⁹

Principles	Practices
Maximize Efficiency	1. Designing the trading algorithm so that a straightforward strategy performs well.
	2. Setting prices in a relatively coarse fashion without significant efficiency loss.
	3. Attaining modest levels of revenue that can be raised with a straight percentage charge and switching to value-added pricing for greater levels of revenue.
Minimize Complexity	4. Creating rudimentary tools to help participants increase market efficiency.
	5. Minimizing algorithmic complexity that makes sensible participation difficult.
	6. Treating somewhat different products as identical to simplify participation.
	7. Permitting iterative adjustment of binding bid and asked prices, which simplifies participant (i.e., buyer and seller) strategies.
Be Transparent and Fair	8. Keeping the exchange neutral, and not heavily tilting it toward one type of participant.
	9. Publishing suitably aggregated marketplace statistics to increase efficiency.
Use Clear and Consistent Language	10. Intentionally designing a language for expressing trades, which accommodates distinctions that matter substantially but not those of lesser importance.

(Source: Guidehouse Insights, R. Preston McAfee and Sergei Vassilvitskii)

While hourly EAC market design carries its own unique challenges (e.g., data availability, accounting requirements, quality assurance of retail claims), the same requisites hold: EAC claims must be based on verified data with zero double counting. According to the EnergyTag Initiative, the design of unbundled hourly EAC markets should feature standardized products, robust price benchmarks, freely accessible supply/demand information, compliance with local contract laws and EAC schemes, alignment with physical energy markets, and harmonized (interconnected) market schemes.⁶⁰ In Europe, Nord Pool and Granular Energy are also working together to advance a framework for granular certificates, and provide multiple market design considerations in their recently issued white paper.⁶¹

“The first revolves around bundling hourly certificates with wholesale power market settlements, as is done today with voluntary, “bundled” PPAs. It is expected that the same trend will play out, with some purchasers opting to bundle hourly certificates with power market settlement contracts.

The second pertains to whether hourly certificates should be geographically restricted within energy price zones. If hourly certificate trading is restricted to a single price area, then existing European marketplaces can accommodate a separate hourly certificate marketplace. However, more sophisticated market integration processes may be needed if cross-border trading is ultimately allowed.”

Proper design is instrumental to the future of unbundled hourly EAC markets. If investors and lenders cannot trust that value and cost realities are reflected in the market, or consumers are apprehensive about pricing transparency or user accessibility, stakeholder attrition is likely to follow.

Measuring Efficacy and Impact

The general consensus is that certificate prices remain the predominant indicator of properly functioning markets. Highlighted in Table 3, interviewees from across the value chain universally cite EAC pricing—

⁵⁹ R. Preston McAfee and Sergei Vassilvitskii: “An Overview of Practical Exchange Design,” *Current Science Association*, 2012.

⁶⁰ “EnergyTag and Granular Energy Certificates: Accelerating the Transition to 24/7 Clean Power,” *EnergyTag*, 2021.

⁶¹ “About Time: How Incorporating Timestamped Energy Certificates Into Electricity Markets Could Accelerate the Energy Transition,” *NordPool, Granular Energy, Afry*, 2023.

and more specifically, transparent, stable, predictable, and informative pricing—as the primary means of evaluating market impact. This is not the only means, however, as indicated by many of these same stakeholders. In theorizing a more holistic approach to evaluating market efficacy and impact, additional performance indicators could include participation metrics (i.e., liquidity), certificate revenues, and long-term marginal emissions rates.

Table 3. Key Stakeholder Insights: Measuring the Impact of Hourly EAC Markets

Auditors, Brokers, Certifiers	Developers	Economists	NGOs
<p>“The question is ‘does the market drive sufficient revenue to make a bankable project.’ If the prices are both low and volatile, regardless of liquidity, that is not an attractive investment thesis. Thus, price stability is crucial.”</p> <p>“The importance of RECs for project financing can be gleaned from REC revenues or market price. It is not as simple as REC revenues are low in comparison to overall project cash flows. It may depend on revenue considered on the margin or other parameters used in project financing decisions.”</p>	<p>“A few different metrics have been tossed around, such as (long-term) marginal emissions rates, but a simpler way is just to look at pricing. Assuming the market is truly liquid, if transactions are north of where the current voluntary market is pegged, or on par with what we are seeing in compliance markets, then the market matters.”</p> <p>“Pricing offers insight into scarcity, interest, robust pricing, etc.—it is one of the critical markets for impact. It is also worth looking at the volume of buyers and sellers looking to participate in the first place; that would come through in terms of liquidity, followed by robust pricing.”</p>	<p>“Measuring the impact will be less about the price of a certificate, and more about proper market design that can facilitate defensible price signals. Poor market design can lead to uninformative pricing signals that fail to reflect value and cost realities.”</p> <p>“If we look at the market for used goods on eBay versus the market for used cars, the former features a wide range of prices for the same products. The latter boasts clear market design and predictable prices (i.e., Kelly Blue Book). The point is that accurate mapping of characteristics into prices is what becomes clear in good market design.”</p>	<p>“In terms of quantifying market impacts, metrics could include e.g., how many people are participating, how many people are trying to cover their load, and how much do EACs cost at certain points in time.”</p>

(Source: Guidehouse Insights, Stakeholder Interviewees)

Conclusions

The development of hourly EAC markets is an important foundation for the clean energy transition. There is near-ubiquitous agreement over the role and relevance of vibrant marketplaces (featuring robust price signals) on system-wide deep decarbonization strategies. While traditional EAC markets demonstrate attributes of liquidity and transparency, concerns have arisen about granularity, additionality, greenwashing, and future viability, and will only be exacerbated moving forward. Yet, industry stakeholders would be wise to avoid moving too quickly so they can ensure the proper standards, enabling technologies, and tracking system capabilities are in place.

As discussed throughout this white paper, employing a gradual approach to granularity would allow corporates to become more comfortable with hourly EACs (perhaps starting with reporting using more granular data and then moving to hourly matching for a portion of their consumption as a glide path to 24/7 CFE). A gradual approach would also allow marketplaces more time to attract sufficient liquidity and solution providers more runway to develop future-proofed enabling technologies. The importance of secondary markets—that is, unbundled hourly EACs markets—in facilitating this transition is well recognized, as these markets can be a significant source of EAC valuation and liquidity. All the pieces are falling into place, from enriched data visualization, tracking, and trading tools to standards development

and improved data accessibility. While the track to hourly EACs is still being laid, the train has clearly left the station, and the headlights are becoming brighter by the day.

Scope of Study

This Guidehouse Insights white paper explores the role that hourly energy attribute certificates (EACs) can play in the energy transition. The future of hourly EACs will ultimately lie in stakeholders' ability to create a vibrant marketplace enriched by an array of buyers and sellers. This study examines the motivations and mechanisms behind the potential design of an hourly EAC marketplace, and is informed by primary interviews with prominent stakeholders throughout the market, as well as an extensive review of publicly available literature.

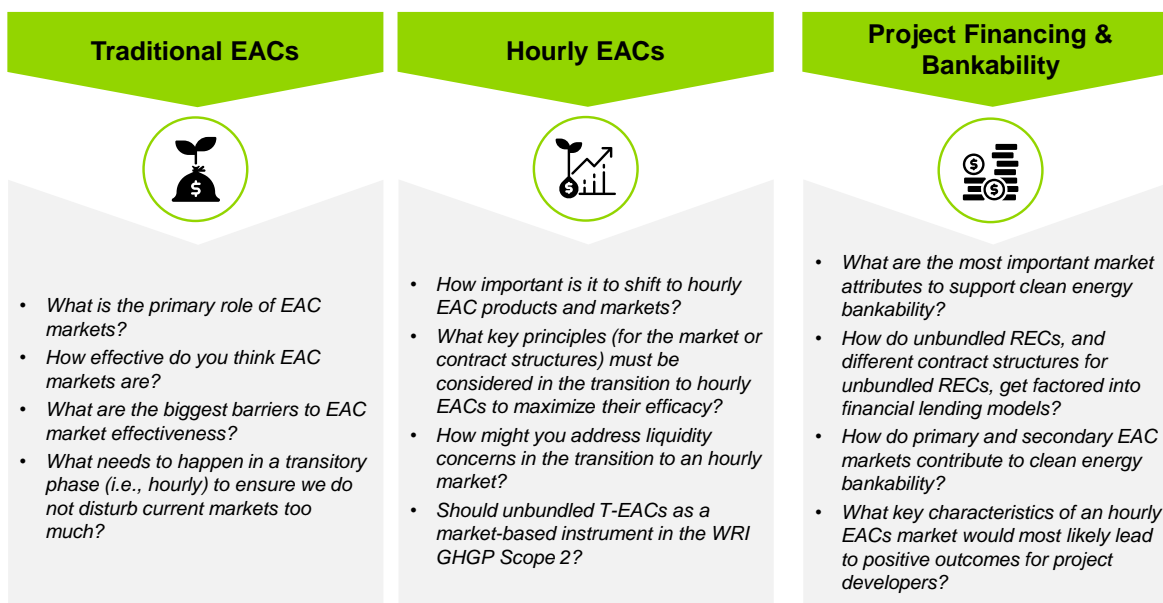
Sources and Methodology

Guidehouse Insights' industry analysts used a variety of research sources in preparing this white paper. The key component of analysis was primary research gained from over a dozen interviews with the following stakeholder groups:

- Auditors and certifiers
- Clean energy investors and lenders
- Clean energy project developers
- Commodity traders and brokers
- Energy and power utilities
- Industry economists
- Non-governmental organizations (NGOs)
- Relevant academics

The diversity of selected interviewees is to ensure that stakeholders perspectives are represented from nearly every part of the value chain. The content scope of these primary interviews emphasized several key research areas, including, but not limited to:

Figure 10. Stakeholder Interview Inquiry Examples



(Source: Guidehouse Insights)

Additional analysis includes secondary research conducted by Guidehouse Insights' analysts and its staff of research assistants. Where applicable, all secondary research sources are appropriately cited in this white paper. These primary and secondary research sources, combined with the analyst's industry expertise, are synthesized into the insights and findings presented throughout this white paper.

Guidehouse Insights is a market research group whose goal is to present an objective, unbiased view of market opportunities in its coverage areas. Guidehouse Insights is not beholden to any special interests and is thus able to offer clear, actionable advice to help clients succeed in the industry, unfettered by technology hype, political agendas, or emotional factors that are inherent in cleantech markets.

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