REGULATORY ASSISTANCE PROJECT

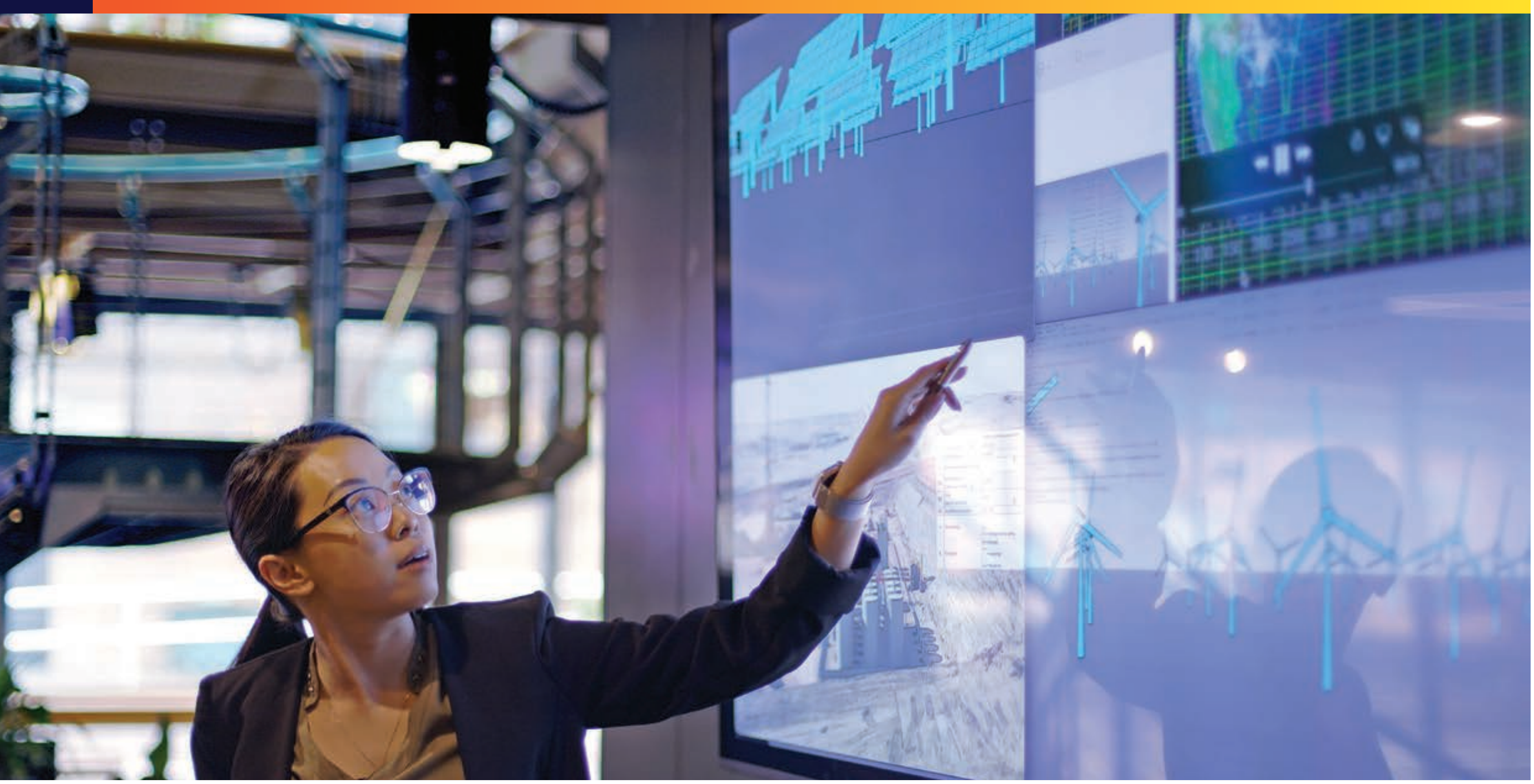
TECHNICAL PAPER

24/7 Carbon-Free Electricity Transition Tariffs

A Regulatory Tool for Accelerating Decarbonization

RAP authors: Carl Linvill, Shawn Enterline, David Farnsworth, Camille Kadoch, Mark LeBel and Nancy L. Seidman

Special advisors: Janet Gail Besser and Ted Thomas



Acknowledgments

The following people helped make our stakeholder process informative and productive through interviews or presentations, provided review and insight during the drafting of this paper, or both.

Leslie Baer, Xcel Energy
Suzanne Belmont, National Renewable Energy Laboratory
Don Bray, Silicon Valley Clean Energy
Raphael Breit, Michael Hogan and Richard Sedano, Regulatory Assistance Project
Cherie Chan, California Public Utilities Commission, Energy Division
Matt Clouse and James Critchfield, U.S. Environmental Protection Agency
Hallie Cramer and Briana Kobor, Google
Killian Daly, EnergyTag
Adam Diamant, EPRI
Neil Fisher, The NorthBridge Group
Josie Gage, Massachusetts Department of Public Utilities
Ben Gerber, M-RETS Inc.
Todd Jones and Rachael Terada, Center for Resource Solutions
Matthew Lehrman, City of Boulder
Trayvon Leslie, Georgia Power
Brian Megali, Constellation Energy
Greg Miller and Wenbo Shi, Singularity
Chris Pennington, Iron Mountain
Jan Pepper, Peninsula Clean Energy (retired)
Elaine Prause and Jessica Shipley, Regulatory Assistance Project (at that time)
Neal Reardon, Sonoma Clean Power
Jason Salmi Klotz, Portland General Electric
Leland Snook, Duke Energy

Donna Brutkoski and Ruth Hare, both of RAP, provided editorial expertise.

March 2024

Regulatory Assistance Project (RAP)®
50 State Street, Suite 3
Montpelier, Vermont 05602
USA

+1 802-223-8199
info@raponline.org

raponline.org
linkedin.com/company/the-regulatory-assistance-project
twitter.com/regassistproj

Cover photo: Laurence Dutton/iStock

Contents

Figures

Tables

Suggested Citation

Linvill, C., Enterline, S., Farnsworth, D., Kadoch, C., LeBel, M., & Seidman, N. L. (2024). *24/7 carbon-free electricity transition tariffs: A regulatory tool for accelerating decarbonization* [Technical paper]. Regulatory Assistance Project.

To be added to our distribution list, please subscribe to our newsletter: https://www.raponline.org/newsletter/

Introduction

Policy and regulatory actions have slowed the growth of carbon emissions, but new tools are needed to target investments to the highest-emissions times and places.

An increasing number of national, state and local government leaders recognize that rapidly decarbonizing the electricity grid is necessary to slow the disruptive effects of a changing climate. At the same time, our lives and livelihoods have never been more dependent on reliable and affordable electricity, as electrification in the building, transportation and industrial sectors accelerates. The challenge for utilities and regulators lies in how to simultaneously fuel economic growth with increased electricity supply while ensuring the electricity is clean and resilient.

Renewable portfolio standards, carbon reduction goals and green power tariffs, among other policy and regulatory tools deployed in recent years, have slowed the aggregate growth of carbon emissions. Public sector and business leaders are now focused on solving three more specific challenges:

1. Decarbonizing high-emissions hours, seasons and places.
2. Building local and national competitive advantage by expanding the hourly availability of clean, resilient electricity supply.
3. Growing carbon-free electricity (CFE) supply that can offer energy and reliability services at times when fossil-fueled resources are currently depended upon.

Meeting these challenges will require new targeted policies to drive resource investments, infrastructure investments and operating practice improvements.

A Princeton University study estimated that the United States needs to invest $2.5 trillion to achieve the carbon reductions required by 2030 to avoid the worst effects of climate change.[1] Public sector leaders have stepped forward to boost investment by advancing the Inflation Reduction Act and Energy Infrastructure Reinvestment loan program and by supporting utility and regulatory commitments to grid-modernization investments in dozens of states through the Grid Resilience and Innovation Partnerships Program.[2] At the local level, governments are offering support for investments in carbon-free distributed energy technologies in their communities.[3] Private sector customers have also stepped forward. For example, many customers have opted in to voluntary "green tariff" programs, offered by utilities to enable customers to support additional investments in renewable energy. Such programs were first approved in Nevada and North Carolina in 2013, and more than 50 programs have now been initiated nationwide.[4] Green tariffs have driven growth of renewable energy on the grid and helped to meet the growing demand for clean power from businesses seeking to achieve their sustainability goals. The success of these programs demonstrates that customer interest in clean energy is at an all-time high, with many willing to pay a premium to participate.

A coordinated approach to public sector, private sector and utility investment that targets high-emissions times and places will clarify the investments required from each entity, avoid

1 St. John, J. (2020, December 17). *Princeton study charts a $2.5T pathway to a net-zero carbon US.* Greentech Media. https://www.greentechmedia.com/articles/read/princeton-study-charts-a-2.5t-pathway-to-a-net-zero-carbon-u.s

2 For more on these programs, see: The White House. (2023, January). *Building a clean energy economy: A guidebook to the Inflation Reduction Act's investments in clean energy and climate action* (Version 2). https://www.whitehouse.gov/cleanenergy/inflation-reduction-act-guidebook/; U.S. Department of Energy. (n.d.). *Energy infrastructure reinvestment.* https://www.energy.gov/lpo/energy-infrastructure-reinvestment; and U.S. Department of Energy. (n.d.). *Grid Resilience and Innovation Partnerships (GRIP) Program.* https://www.energy.gov/gdo/grid-resilience-and-innovation-partnerships-grip-program

3 For example, local governments served by Sonoma Clean Power, a community choice aggregator in California, have opted in to its 24/7 carbon-free electricity tariff. Sonoma Clean Power. (n.d.). *Electrify everything.* https://sonomacleanpower.org/uploads/documents/Annual-Report-2021-FINAL.pdf

4 Clean Energy Buyers Association. (2023). *U.S. utility green tariff report.* https://cebuyers.org/wp-content/uploads/2023/04/Final-CEBA_Green-Tariff-Report.pdf

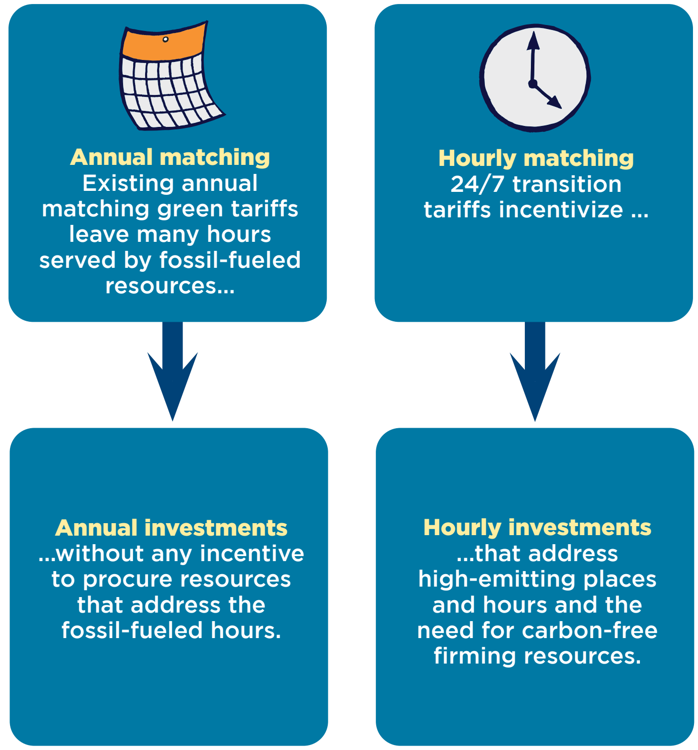
duplicative investments and keep costs more manageable for all utility customers. This level of coordination requires investments that are more targeted than those induced by legacy green tariff programs. Technology is available now to help, and a more targeted tariff can bring public, private and utility capital together to decarbonize the grid more effectively, equitably and reliably. A 24/7 carbon-free electricity transition tariff is a tool to accelerate decarbonization generally while addressing times and places on the grid where emissions have been most difficult to reduce.

Figure 1 illustrates the opportunity presented by a 24/7 transition tariff, and the text box below defines how a 24/7 transition tariff differs from a legacy green tariff using annual matching.

Fortunately, progress is already underway. The federal government and some U.S. states and local governments have adopted new zero-carbon energy policies since 2015.

At the same time, corporate customers have procured over 95 GW of new renewables. These public, private and community electricity customers in aggregate represent a large amount of electric load and bring significant investment capital to accelerate decarbonization. Over the last few years, some of these public and private sector customers have started negotiating tariffs with

Figure 1. Hourly matching tariffs induce investment that is more targeted



their host utilities that move in the direction of the 24/7 transition concept.

The opportunity to standardize tariffs to accelerate offerings and adoption in many more places led the Regulatory Assistance Project (RAP) to initiate the project described in this report, a comprehensive initiative to define the optimal design of 24/7 transition tariffs and contracts for participants

How is a 24/7 carbon-free electricity transition tariff different?

24/7 carbon-free electricity transition tariffs are different from the green tariffs that match annual consumption with annual renewable energy production. 24/7 transition tariffs seek to match a customer's hourly consumption with deliverable carbon-free electricity provision in each hour of the year. We refer to this concept as a "transition" tariff because it is designed to accelerate the transition of the electric grid to carbon-free sources. Complete hourly matching will require investments and changes in operating practices that address high-emitting hours and high-emitting locations on the grid, where generation still depends on fossil resources, and full decarbonization of the grid requires these investments and changes in operating practices. Annual-matching green tariffs do not induce these investments or change practices, but with the move toward more granular time matching, 24/7 transition tariffs can accelerate progress toward full decarbonization.

and broader electricity systems. Throughout 2023, RAP worked with a group of stakeholders to develop guidance on how green tariff programs may evolve to best meet the needs of today's grid. The goal was to make a set of recommendations for 24/7 transition tariffs that could accelerate decarbonization while incentivizing investments that bolster grid reliability and resilience.

When well-designed, a 24/7 transition tariff can empower utilities and customers to collaborate on accelerating the grid's shift to clean energy. By focusing on the grid's hourly operations, a transition tariff allows customers to move toward matching their electricity consumption with carbon-free resources on an hour-by-hour basis — revealing previously neglected opportunities to reduce emissions at particular times or places. Throughout this process, we carefully considered diverse market structures and customer priorities to ensure broad applicability. This report details our process, findings and recommendations for fundamental principles to guide the development of effective 24/7 carbon-free electricity transition tariffs.

The 24/7 Transition Tariff Project Process

Between March and November 2023, RAP hosted monthly meetings with a diverse and highly engaged group of stakeholders, offering multiple avenues for feedback on draft documents and presentations. Utilities, a variety of end users, federal and state governments, and nonprofits across the country actively participated. With an average of 60 attendees per meeting and 140 stakeholders on our distribution list, the process garnered significant input and benefited from broad representation.

To ensure that stakeholders were identifying and prioritizing key questions, we organized participants into three specialized working groups, each also joined by relevant subject-matter experts. Each group delved into a specific topic pertinent to the successful implementation of 24/7 transition tariffs. The findings and recommendations of the working groups, along with research undertaken by RAP staff, are explored in more detail in four appendices.

Appendix A: Resource Planning Requirements describes the planning processes to guide optimal integration of 24/7 CFE portfolios into ongoing utility and system planning. This appendix concludes with recommendations for improving planning to support better tariffs in the near term.

Appendix B: Emissions Tracking and Verification describes best practices for tracking and matching emissions to generation, and practices required to ensure 24/7 CFE portfolios produce the intended emissions outcomes. This appendix offers recommendations for improving emissions tracking in the near term.

Appendix C: Rate-Making, Pricing and Resource Compensation offers best practices for rate-making and discusses how they apply in various 24/7 CFE contexts. This appendix then turns to near-term recommendations for improving 24/7 transition tariffs.

Appendix D: Operational Requirements describes the requirements to effectively implement integrated 24/7 CFE portfolios in distribution and bulk system operations. This appendix concludes with recommendations for improving operations to support better tariffs in the near term.

RAP's extensive research and guidance from the stakeholder working groups resulted in the identification of key elements that provide the basis for the fundamental design recommendations made in this report. These fundamentals are intended to help regulators, utilities and customers develop 24/7 transition tariff offerings that can accelerate decarbonization while advancing the public interest.

Five Fundamentals

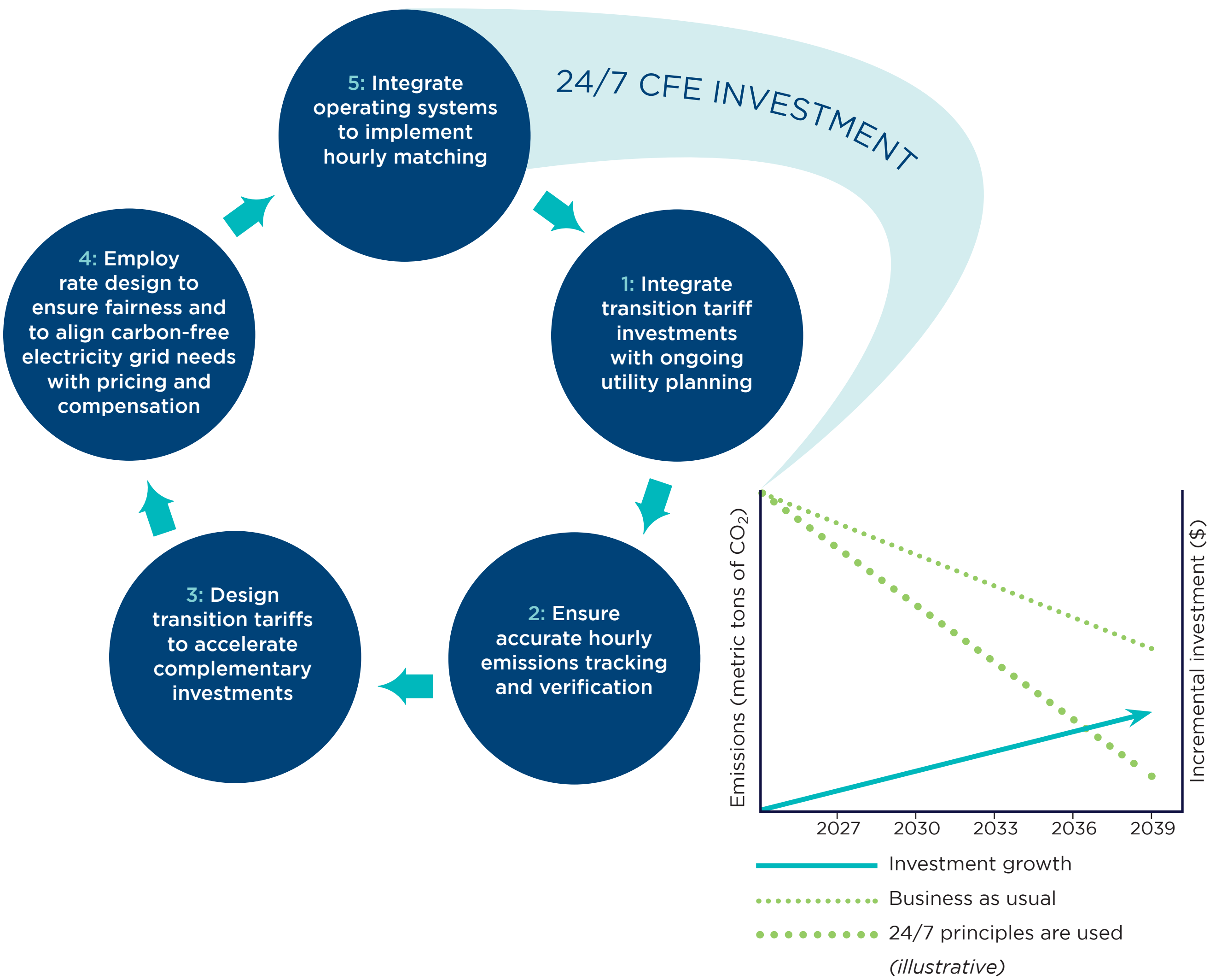
These are the foundation of a well-designed 24/7 transition tariff, adaptable to individual market needs and tailored to specific customer and policymaker objectives.

Daniel Balakov/iStock

Our research and stakeholder engagement identified five fundamentals that should serve as the foundation of a well-designed 24/7 carbon-free electricity transition tariff. These can create a robust and impactful tariff design, adaptable to individual market needs and tailored to specific customer and policymaker objectives.

The five fundamentals are summarized in Figure 2. Applying them in the initial design of a 24/7 transition tariff induces a first round of investment and policy changes that incentivize accelerated decarbonization of the grid on an hourly basis. Every three years or so, the design process should be revisited to encourage subsequent rounds of investment and policy changes that build upon the previous period. Over time, the repeated application of these fundamentals will increase focused investment in carbon-free resources that firm up electricity supply and build local carbon-free resilience, while accelerating progress toward aggregate carbon emissions reductions.

Figure 2. Fundamentals of a 24/7 transition tariff



FUNDAMENTAL 1

Integrate transition tariff investments with ongoing utility planning

24/7 CFE portfolios need to be co-optimized and aligned with a comprehensive planning approach. Adapting the planning process to integrate 24/7 portfolios will take time, but it is never too early to improve planning to enhance alignment. 24/7 portfolios may increase or decrease costs relative to the legacy plan. They may also introduce incremental benefits relative to the legacy plan. Therefore, accurately assessing benefits and costs requires integration of the 24/7 portfolio into a comprehensive planning process, such as one consistent with the recommendations of the Task Force on Comprehensive Electricity Planning convened by the National Association of Regulatory Utility Commissioners (NARUC) and the National Association of State Energy Officials (NASEO).[5]

From a technical perspective, an effort should be made to identify the resources that support the tariff and co-optimize these carbon-free resources with existing resources. From an administrative perspective, it's important to map the pricing, terms, conditions and implementation details that are necessary to administer the tariff. Finally, regulators must weigh the various goals of stakeholders, balance their interests and determine how the 24/7 portfolio affects the benefits and costs experienced by all customers.

Annual-matching green tariffs lead to least-cost-per-kWh investment without regard to the time and place of power generation, which leads to large-scale wind and solar development, often in remote locations. Although developing these resources is necessary and beneficial, addressing the hourly and seasonal challenges in specific regions and in specific distribution utility footprints requires investment in carbon-free electricity that is more targeted. Advanced geothermal energy, long-duration energy storage, green hydrogen, advanced nuclear and aggregated distributed energy resources each offer location-specific carbon-free solutions but tend to be overlooked in annual-matching programs.

A well-designed process that co-optimizes utility planning and procurement with 24/7 transition tariff planning and implementation can combine customer and utility investment to develop local resources most cost-effectively for the benefit of all customers. A 24/7 transition tariff should reflect the NARUC-NASEO task force's recommended planning process and the principles of 24/7 carbon-free electricity described below in Recommendation 1, which are addressed more fully in Appendix A.

5 National Association of Regulatory Utility Commissioners. (n.d.). *Task force on comprehensive electricity planning.* https://www.naruc.org/committees/task-forces-working-groups/retired-task-forces/task-force-on-comprehensive-electricity-planning/home/

Table 1. Carbon-free electricity principles for 24/7 transition tariff design

Principle	Application
Aggregated supply matched to aggregated demand	CFE tariffs require a series of one-to-one obligations (load-serving entity* to customer) that are collectively met using a many-to-many relationship (i.e., many supplies to many demands).
Time-matched procurement	CFE tariffs attribute the emissions from electricity generation to the same hour as the customer's consumption.
Geographic deliverability	CFE tariffs identify the market and geographic boundaries within which the utility or load-serving entity will procure generation resources to match with customer load.
Technology neutrality	CFE tariffs may include any carbon-free electricity technology.
Enabling of new resources	CFE tariffs focus on enabling new clean electricity generation that supports the rapid decarbonization of electricity systems.
Attributional market-based emissions accounting	Utilities implementing CFE tariffs will depend on "attributional, market-based" emissions accounting that proceeds from the bottom up, where actual, individual resource-by-resource generation is attributed using the contractual obligations between the owners of individual resources and their customers.
Measurable system impact	Resource planning uses both attributional and consequential accounting to estimate the emissions impact of the new CFE resources that are supporting the tariff or product offering.
Fairness to all participants	CFE resources will have benefits and costs, and these should be allocated fairly between participants and nonparticipants alike.

** We use the term "load-serving entity" to include utilities in regulated jurisdictions and utilities and retail suppliers in restructured jurisdictions.*

RECOMMENDATION 1:

Implement transition tariffs that are based on 24/7 carbon-free electricity principles and integrate them with utility resource planning.

- Table 1 lists the principles that should be adopted to support the development of reliable, affordable and clean 24/7 transition tariff portfolios. These principles need to be recognized and integrated with legacy utility planning practices to support the co-optimization of transition tariff and utility resource planning.

RECOMMENDATION 2:

Implement the three-part process recommended by the NARUC-NASEO energy planning task force as 24/7 transition tariffs are integrated, with an eye toward immediate progress and longer-term alignment.

- The planning steps relevant to this design process recommended by NARUC-NASEO[6] include early stakeholder engagement, integration of distribution system planning with bulk system planning, and alignment of planning with the market and regulatory structure in the applicable utility and bulk market service territories.

6 NARUC-NASEO Task Force on Comprehensive Electricity Planning. (2021). *Blueprint for state action.* National Association of Regulatory Utility Commissioners and National Association of State Energy Officials. https://pubs.naruc.org/pub/14F19AC8-155D-0A36-311F-4002BC140969

FUNDAMENTAL 2

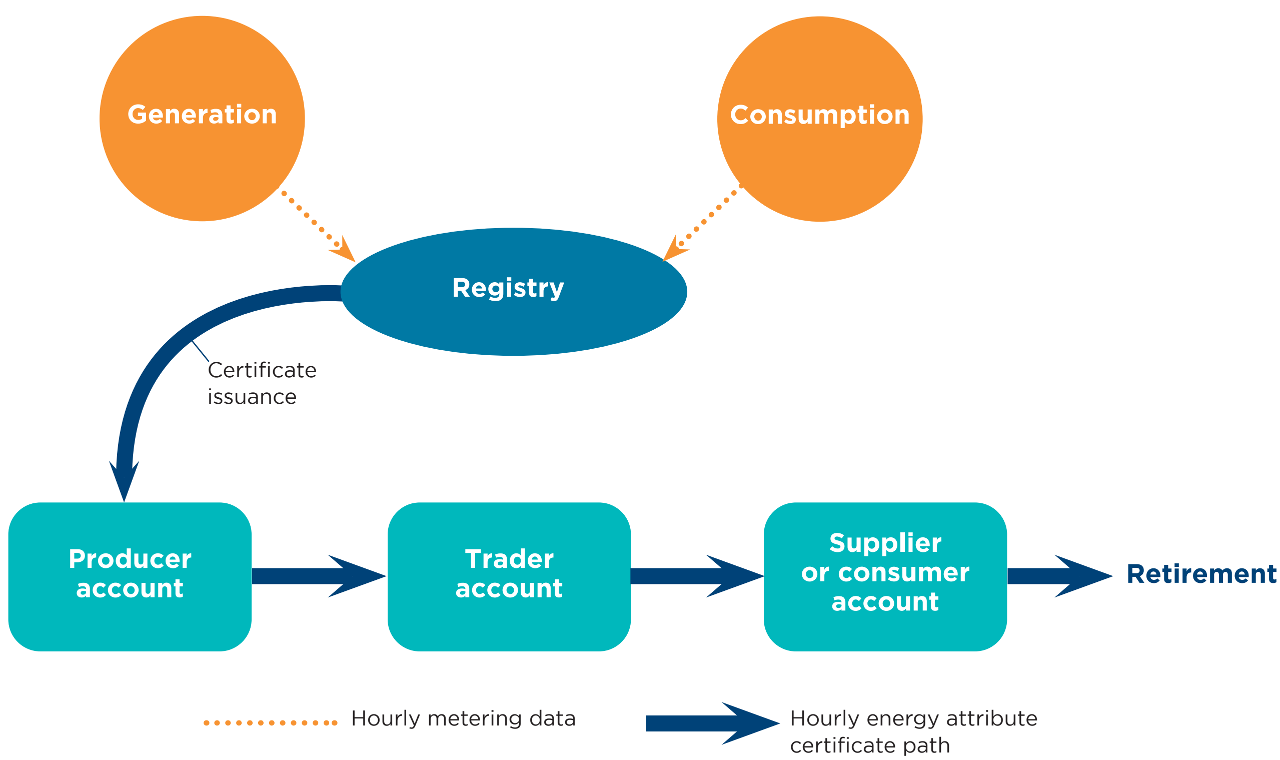
Ensure accurate hourly emissions tracking and verification

A successful 24/7 transition tariff requires the ability to match hourly customer load with hourly electricity supply. To enable such matching, a load-serving entity would need to produce hourly customer load data that could be matched with time-stamped (hourly) energy attribute certificates, ideally from a standardized, national, all-generation tracking system or systems, as illustrated in Figure 3.[7]

The functions necessary to enable 24/7 hourly matching include connecting corresponding hourly consumption data with energy data and the issuing, tracking and retirement of the related certificates. With this capability, a load-serving entity can demonstrate that the generation and related hourly emissions from its resource portfolio are matched with the time and location of the customer's energy use.

A national, all-generation tracking system (or systems) would provide an ideal platform to meet the accounting and tracking requirements needed for a 24/7 transition tariff. While the United States

Figure 3. Functions in hourly carbon-free electricity matching



Source: Adapted from EnergyTag. (2021). *EnergyTag and Granular Energy Certificates: Accelerating the Transition to 24/7 Clean Power*

7 Adapted from EnergyTag. (2021). *EnergyTag and granular energy certificates: Accelerating the transition to 24/7 clean power.* https://www.energytag.org/wp-content/uploads/2021/05/EnergyTag-and-granular-energy-certificates.pdf

currently has no one system capable of doing this, several registries across the country — M-RETS in the Midwest, PJM's Generation Attribute Tracking System and the North American Renewables Registry — have begun to implement hourly tracking in some capacity.

A productive near-term approach, one that has been adopted in Europe, would be for existing tracking systems to meet the same standards and follow similar practices.[8] Developing this capacity at load-serving entities will require the standardization and adoption of a series of emissions tracking procedures and related practices, including standardized approaches to CFE certificate production, emissions tracking, customer load data provision, market boundary establishment, and allocation of existing CFE. These topics are outlined briefly below in five recommendations and are discussed more fully in Appendix B.

RECOMMENDATION 1:

Load-serving entities should provide hourly customer load data in a standardized format.

- For customers to understand their energy use and for systems to be interoperable across different jurisdictions developing 24/7 transition tariffs, utilities should adopt accounting systems with consistent reporting formats.

RECOMMENDATION 2:

Employ consequential and attributional accounting to understand, respectively, the effects on system emissions and the emissions characteristics of resources procured to match consumer load.

- Load-serving entities should recognize that complementary emissions accounting approaches are required to understand the implications of adopting 24/7 tariffs.

RECOMMENDATION 3:

Rely on the publicly available emissions data or best available calculated emissions and energy data to populate energy attribute certificates.

- In populating emissions accounting systems, load-serving entities should recognize that relevant emissions data is generally publicly available. If it is not, they should calculate emissions and energy data based on the best available information.

RECOMMENDATION 4:

Define geographic market boundaries based on energy delivered, or capable of being delivered, into one's local service area.

- Articulating market boundaries and promoting energy delivery are important in voluntary clean energy markets where buyers claim to consume the clean energy that they purchase.

RECOMMENDATION 5:

States should ensure that participating and nonparticipating consumers are treated fairly in the allocation of existing carbon-free electricity in a load-serving entity's resource mix to customers under a 24/7 tariff.

- As states explore the adoption of 24/7 tariffs, it is important to support first movers, but also to avoid harming nonparticipants.

8 The European Union allows member states to have their own tracking system, but each system must work within the Association of Issuing Bodies framework. This framework contains common standards for all tracking systems — for example, the requirement that they audit each other annually for compliance and accountability purposes. Association of Issuing Bodies. (n.d.). *AIB guaranteeing the origin of European energy.* https://www.aib-net.org/

FUNDAMENTAL 3

Design transition tariffs to accelerate complementary investments

A well-designed 24/7 transition tariff program should consider existing and planned utility investments to ensure that customer-driven investments add value. By using these existing resources as a baseline, the program can effectively incentivize investments in the resources and infrastructure most needed to accelerate grid decarbonization without compromising reliability or resilience.

For instance, a utility focused on decarbonization might already have significant investments in solar photovoltaics. In such cases, additional customer-specific procurement of solar may have minimal impact on incremental carbon reduction. To address this, the program should build on the existing and planned utility portfolio as the starting point and enable customers to understand and quantify how much their energy usage aligns with hourly clean energy, even without the tariff. This "clean energy load share" information helps regulators and policymakers assess the true impact of customer-specific resources on the system.

RECOMMENDATION:

Factor in existing investments while providing transparency to customers, so that the program can ensure that customer-driven investments are truly complementary and accelerate decarbonization.

- Customers need to be able to clearly understand when clean energy will be available from the grid when making their investment decisions.

Windzepher/iStock

FUNDAMENTAL 4

Employ rate design to ensure fairness and to align carbon-free electricity grid needs with pricing and compensation

Pricing and compensation decisions affect both fairness in the near term and the pace of progress toward efficient, equitable and reliable decarbonization in the years to come.

Ensuring equitable rate-making and compensation depends upon coordinating existing and ongoing utility plans as tariff terms and conditions are determined. Fundamentals 1 and 3 in this paper focus on determining the investments needed to implement and align 24/7 CFE portfolios with legacy utility planning. The rate-making process will, in turn, establish fair cost allocation, pricing and compensation decisions that advance the public interest. These rate-making decisions are especially important because the pricing and compensation decisions will drive future utility and non-utility investment decisions. Pricing and compensation decisions thus affect both fairness in the near term and the pace of progress toward efficient, equitable and reliable decarbonization in the years to come.[9]

In practical rate-making, policymakers and stakeholders must balance a range of objectives that are frequently in tension with each other, including (1) effective recovery of the utility's revenue requirement, (2) customer understanding of their rates and bills, (3) equitable allocation of costs among customers and (4) efficient price signals. As with any specific tariff, fair and reasonable rates will be a function of the specific market context and should be fully vetted by the stakeholders in that market.

From a regulatory perspective, the simplest rate-making context for customer adoption of 24/7 CFE resources is in restructured jurisdictions. In those jurisdictions, customers are already empowered to negotiate alternative supply arrangements with non-utility suppliers, and existing rate-making structures enable the utility to recover the costs it incurs for delivering this electricity and providing metering, billing and other services.

Table 2 on the next page shows the issues that come into play in implementing a 24/7 transition tariff in vertically integrated jurisdictions.

9 For more on designing pricing that meets grid needs, see: Energy Systems Integration Group. (n.d.). *Aligning retail pricing and grid needs.* https://www.esig.energy/aligning-retail-pricing-with-grid-needs/

Table 2. Issues and options for 24/7 transition tariff rates in vertically integrated jurisdictions

Issue	Options	Comments
Foundation for rate structure	• Full existing rate • Existing transmission and distribution rate plus new program-specific generation rate • Entirely new rate	Additional charges and credits can be structured around these foundational options.
Eligible load	• New load only • Existing load only • New or existing load	Categories of eligible load may influence what types of incremental charges may reasonably be placed on participating customers.
Incremental costs from 24/7 CFE program	• Administrative costs • Interconnection fee for new resources • Incremental transmission costs • Grid integration costs • Utility incentives • Certain costs for existing generation assets*	Any incremental costs should be properly documented and evaluated for appropriate cost allocation across participating and nonparticipating customers.
Incremental benefits from 24/7 CFE resources	• Fuel and purchased power cost or wholesale market energy cost reduction • Generation resource adequacy contribution or wholesale market capacity cost reduction • Transmission or distribution cost reduction • Resilience benefits • Environmental and public health benefits	Incremental benefits should be properly estimated based on a reasonable value of the resources with appropriate reforms to forward-looking planning.
Length of arrangement	• Term of contract (e.g., 10 years) • Charges for switching back to utility from alternative supply	Additional restrictions may impede 24/7 transition tariff adoption but provide greater certainty for the utility and nonparticipating customers.

** Changes in investment requirements associated with 24/7 CFE portfolio implementation may make some legacy investments uneconomic and may make planned investments unnecessary. Whether this creates a net cost or a net benefit for nonparticipating ratepayers is an important issue that requires quantitative analysis with planning scenarios.*

Some customers adopting 24/7 CFE may wish to include their own on-site clean distributed energy resources in their portfolios. Their decision to do so may be influenced by state-level net metering policies or other compensation policies for on-site distributed energy resources. See the subsection on distributed energy resources in Appendix C for more information.

There are numerous reasonable combinations of choices on these issues, but several key recommendations stand out.

RECOMMENDATION 1:

Determine net costs using integrated planning.

- The net costs of designated CFE resources, as well as their system benefits, should be informed by an integrated assessment of the host utility resource plan and the proposed CFE resource portfolio in those jurisdictions where the utility prepares an integrated resource plan.

RECOMMENDATION 2:

Allocate net costs of CFE to participating customers.

- Participating customers should cover the net costs of the designated CFE resources after all costs and benefits to nonparticipating customers have been accounted for.

RECOMMENDATION 3:

Design incentives to manage the demand side.

- The transaction should be structured to provide reasonable incentives for the management of customer load, and the system benefits provided by well-managed load should be compensated fairly.

RECOMMENDATION 4:

Plan to co-optimize customer and utility investments.

- Opportunities for co-optimizing participating customer investments and utility investments should be evaluated and implemented for the benefit of all consumers.

FUNDAMENTAL 5

Integrate operating systems to implement hourly matching

Hourly matching is a key feature of any CFE resource portfolio, and it implies that the supply of CFE matches the electricity demand at hourly or sub-hourly intervals. However, CFE supplies and electricity demand do not need to be perfectly matched[10] in every hour to offer a CFE product. The purpose of transition tariffs is to make progress toward 100% CFE and to report the level of CFE matching to the customers who subscribe to the product in the interim.

In any case, implementing hourly matching will require greater levels of system integration and interoperability. The data and functional requirements that will enable hourly matching are being collaboratively developed under the leadership of organizations like the National Institute for Standards and Technology (NIST) and EnergyTag.[11] These collaborations and the standards that they publish are essential resources and will be important to consult as CFE portfolios are being designed and implemented.

Multiple operating systems must be integrated over several functional areas. Making all these areas interoperable is desirable over time but is not necessary for a 24/7 transition tariff.

Multiple operating systems must be integrated over several functional areas, as discussed in Appendix D. These systems can be grouped into seven "domains" as described by NIST in Table 3 on the next page.[12]

Making all these domains interoperable is desirable over time, but it is not necessary for a 24/7 transition tariff. Significant progress can be made in advance of that future state by increasing the time granularity of existing systems in the customer domain and integrating them with existing systems in the market domain that are already time granular.

10 Matching CFE supplies to demand 100% of the time is not yet an operational reality in regions without large surpluses of hydroelectricity to serve as storage that can be dispatched later.

11 In addition, LF Energy Standards and Specifications (https://lfess.energy) is developing the open-source Carbon Data Specification project, which introduces specifications to enable more streamlined and standardized customer data and power systems data access to serve a 24/7 accounting use case.

12 Gopstein, A., Nguyen, C., O'Fallon, C., Hastings, N., & Wollman, D. (2021, February). *NIST framework and roadmap for smart grid interoperability standards, release 4.0*, Table 1, p. 16. National Institute for Standards and Technology. https://www.nist.gov/publications/nist-framework-and-roadmap-smart-grid-interoperability-standards-release-40

Table 3. Operating system domains

Domain	Roles/services in the domain
Customer	The end users of electricity. May also generate, store and manage the use of energy. Traditionally, three customer types are discussed, each with its own subdomain: residential, commercial and industrial.
Markets	The facilitators and participants in electricity markets and other economic mechanisms used to drive action and optimize system outcomes.
Service provider	The organizations providing services to electrical customers and to utilities.
Operations	The managers of the movement of electricity.
Generation, including distributed energy resources	The producers of electricity. May also store energy for later distribution. This domain includes traditional generation sources and distributed energy resources. At a logical level, "generation" includes those traditional larger-scale technologies usually attached to the transmission system, such as conventional thermal generation, large-scale hydro generation and utility-scale renewable installations. Distributed energy resources are associated with generation, storage and demand response provided in the customer and distribution domains and with service provider-aggregated energy resources.
Transmission	The carriers of high voltage electricity over long distances. May also store and generate electricity.
Distribution	The distributors of electricity to and from customers. May also store and generate electricity.

Source: Gopstein, A., Nguyen, C., O'Fallon, C., Hastings, N., & Wollman, D. (2021, February). *NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 4.0*

For example, the simplest 24/7 transition tariff would be a completely static product where the level of CFE is reported after the operating day is complete. This type of 24/7 transition tariff would represent an *ex post* product, as it would not attempt to dispatch supply or demand in real time. As a result, it would essentially be offering customers a portfolio-design and reporting service. This kind of service could use the customer's monthly bill to report the percentage of CFE that was delivered into the local utility service area in each hour. The systems that would be required to match supply with demand could be limited to three systems: (1) the customer's metering system, which measures demand, (2) the energy market clearinghouse, which measures supply, and (3) the service provider(s) who provide the hourly matching and billing systems.

The most dynamic 24/7 transition tariff would be one where CFE supply and electricity demand are scheduled in advance of the operating day and dispatched in real time. This kind of service would be offered on an *ex ante* basis and would probably rely on high levels of system integration among all seven functional areas. Naturally, there is a range of intermediate cases that would require a less comprehensive level of system integration.

Regardless of the type of product being offered, three high-level recommendations should be followed when designing and implementing the operating systems that support 24/7 transition tariffs.

RECOMMENDATION 1:

Consult the latest standards when developing CFE products.

- Following standards from NIST, EnergyTag and others helps ensure that CFE products can be seamlessly tracked and traded between power marketers, utilities and the balancing authorities charged with ensuring local reliability.

RECOMMENDATION 2:

Implement CFE products based on actual data first.

- *Ex post* implementations of CFE products represent a relatively straightforward and necessary first step in CFE tracking and system development.

RECOMMENDATION 3:

Implement CFE products based on forecast data second.

- *Ex ante* implementations of CFE products will be needed to reach 100% CFE, which implies the need for high levels of system integration.

Conclusion

Well-designed 24/7 carbon-free electricity transition tariffs can accelerate decarbonization by addressing several challenges that current policies have not solved.

imagedepotpro/iStock

Legacy decarbonization and renewable energy policies have contributed to a cleaner grid, but accelerating this shift requires new policies and regulatory tools that can address gaps in the decarbonization progress. Well-designed 24/7 carbon-free electricity transition tariffs have the potential to speed up change because they address several challenges that current policies have not solved. These tariffs can:

- Induce carbon-free electricity resource and infrastructure investments to displace fossil generation in high-emitting hours and places.
- Coordinate utility and non-utility investments for the benefit of all consumers, including 24/7 participants and nonparticipants.
- Drive development of carbon-free electricity resources that offer energy and reliability services currently provided mostly by fossil-fueled generation.

Fortunately, some customers and utilities have already partnered on 24/7 transition tariffs. These customers include the federal government, state and local governments, community choice aggregators and certain large customers. Despite strong customer interest, relatively few tariffs have been established, and many customers do not yet have access to a well-designed 24/7 transition tariff. There are lessons to be learned from the efforts to date. RAP's 24/7 transition tariff investigation and stakeholder process has examined the early adoptions to establish guidance for regulators, utilities and electricity customers on designing 24/7 transition tariffs.

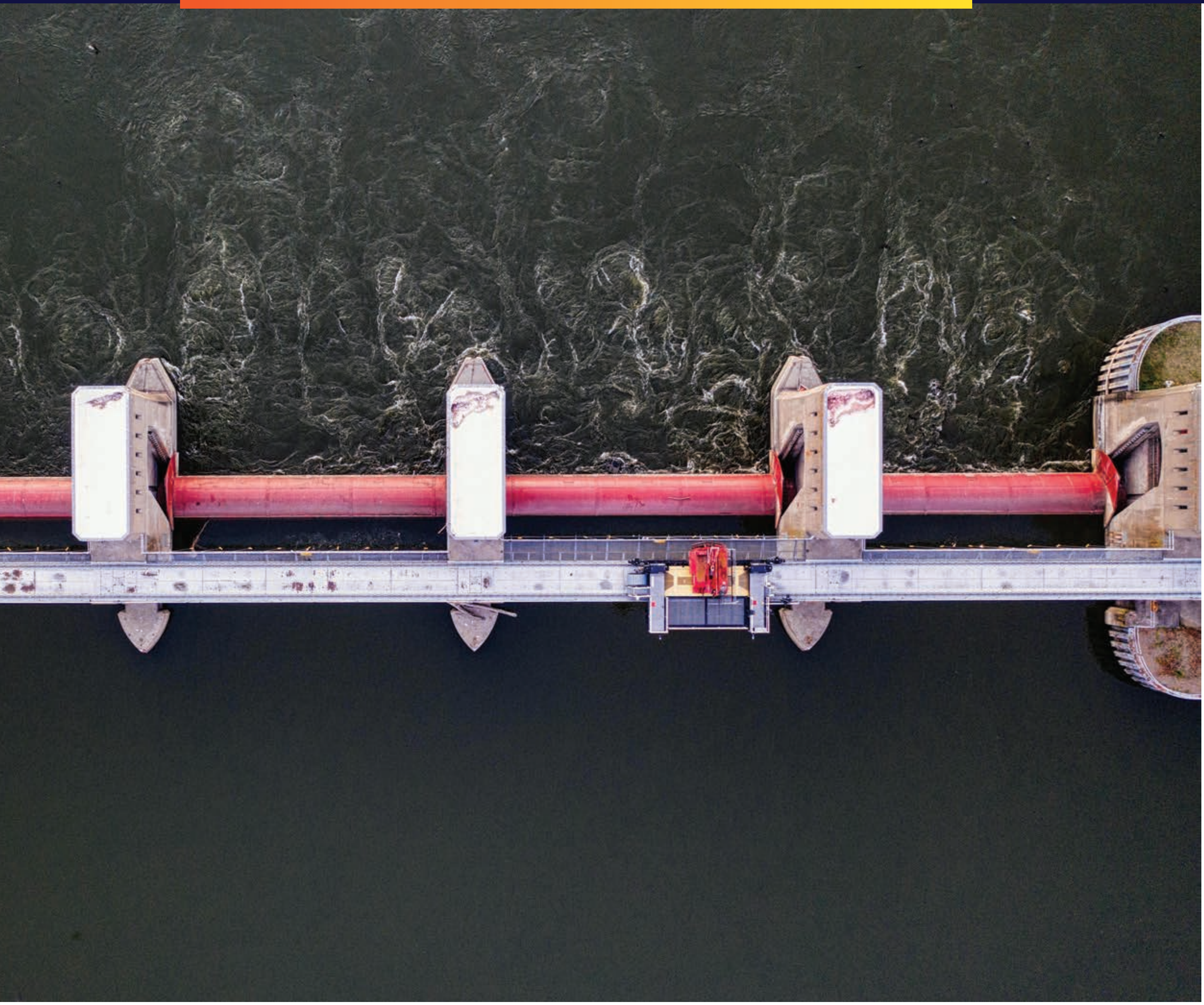
RAP identified five fundamentals that can lower the transaction costs of establishing new tariffs while producing tariffs that induce reliability, resiliency and cost benefits for 24/7 participants and nonparticipants alike. The five fundamentals are:

1. Integrate transition tariff investments with ongoing utility planning.
2. Ensure accurate hourly emissions tracking and verification.
3. Design transition tariffs to accelerate complementary investments.
4. Employ rate design to ensure fairness and to align carbon-free electricity grid needs with pricing and compensation.
5. Integrate operating systems to implement hourly matching.

Well-designed 24/7 transition tariffs are a tool available to customers, utilities and regulators that can accelerate decarbonization by addressing gaps in progress more-established approaches have been unable to bridge.

Appendices

24/7 carbon-free electricity is a complex topic. These four appendices provide more in-depth detail and thinking on the resources, emissions, rate-making and operational aspects.



Tom Fisk/Pexels

Introduction to the Appendices

Customers who are seeking to decarbonize their electricity consumption during every hour of the day face a high-level challenge. Most existing green tariffs were developed under the auspices of 100% annual renewable energy goals and are often not well suited to hourly matching initiatives. To align the goals of these customers with the needs of a decarbonizing grid, RAP convened stakeholder work groups to develop regulatory tools that can be tailored for use in all 50 states.

We refer to the product that these customers are seeking as a 24/7 carbon-free electricity transition tariff, and it applies primarily to jurisdictions that are vertically integrated. In the context of retail deregulated jurisdictions, the same product can be offered by competitive suppliers using a bilateral contract — that is, without a tariff. This research uses the term "24/7 transition tariff" to refer to both products. The purpose of 24/7 carbon-free electricity (CFE) products is to stimulate a transition to a future where hourly matching happens on a 24/7 and 365-day basis while recognizing that today's commercial and operational reality falls short of this ideal.

Our research and interviews identified four issues that all 24/7 CFE products will need to address.

1. **Resources:** Identifying eligible carbon-free and low-carbon technologies and documenting the hourly products (energy, capacity, ancillary services) that they can produce.
2. **Emissions:** Accurately tracking and reporting the hourly carbon emissions associated with the participant's resource portfolio as it transitions to 100% 24/7 CFE.
3. **Rate-making:** Ensuring that rate-making and resource compensation support the feasibility and long-term sustainability of 24/7 CFE.
4. **Operations:** Ensuring that the operational systems that support 24/7 transition tariffs are interoperable.

Each of the four appendices focuses on a different one of these challenges.

Appendix A: Resource Planning Requirements

Lead authors: Shawn Enterline and Carl Linvill

This appendix develops eight principles for 24/7 carbon-free electricity (CFE) resources and proposes eligibility and data requirements that can be applied to 24/7 transition tariffs. It is organized into four sections:

1. Principles
2. Eligibility Requirements
3. Data Requirements
4. Recommendations

Principles

To develop high-level eligibility requirements, RAP's Resources Work Group first compiled both the principles for 24/7 CFE articulated by the 24/7 Carbon-Free Energy Compact and the recommendations of RAP's Emissions Tracking Work Group. The resources group then made its own additions and modifications. The resulting eight principles of 24/7 CFE are applied to resource-related issues in this appendix but are expected to apply generally to the development of 24/7 transition tariffs. They may be applied, for example, to subsequent work on the emissions and rate-making topic areas.

24/7 Carbon-Free Energy Compact

The 24/7 Carbon-Free Energy Compact defines five principles as the basis of 24/7 CFE:[1]

1. **Time-matched procurement:** "24/7 CFE focuses on matching each hour of electricity consumption with carbon-free electricity generation. Hourly matching helps connect clean energy purchasing to underlying electricity consumption."
2. **Local procurement:** "24/7 CFE means purchasing clean energy on the local/regional electricity grids where electricity consumption occurs. This is the only way to drive the electricity-related emissions that a consumer is directly responsible for to zero."
3. **Technology-inclusive:** "24/7 CFE recognizes the need to create zero-carbon electricity systems as fast as possible, and that all carbon-free energy technologies can play a role in creating this future."
4. **Enable new generation:** "24/7 CFE focuses on enabling new clean electricity generation, in order to support the rapid decarbonization of electricity systems."
5. **Maximize system impact:** "24/7 CFE focuses attention on maximizing emissions reductions and solving for the dirtiest hours of electricity consumption."

1 24/7 Carbon-Free Energy Compact. (n.d.) *Call to action: 24/7 carbon-free energy compact to accelerate the decarbonization of electricity grids.* https://www.un.org/sites/un2.un.org/files/2021/09/principles_-_updated.pdf

Emissions Tracking Work Group Recommendations

The working group's recommendations are summarized below.

Load-serving entities offer a 24/7 CFE product or tariff with the intent to aggregate customers' demand and match it up to a portfolio of supplies. A 24/7 CFE offering creates a series of one-to-one obligations (LSE to customer) that are collectively met using a many-to-many relationship.

- **Time-matching.** A 24/7 transition tariff should attribute the emissions associated with electricity generation to the same hour as when the customer's consumption occurs. Requiring hourly matching between supply and demand honors the physical, moment-to-moment matching that must take place to maintain the grid, and it aligns well with the market-based, hourly settlement processes that balancing authorities (BAs) use.
- **Attributional accounting.**
  - 24/7 CFE accounting should proceed from the bottom up by accounting for the actual, individual resource-by-resource generation and characteristics of the power delivered to the consumer.
  - This recommendation implies the use of an all-generation tracking system and/or best practices that use hourly matching of supply, demand and emissions.
  - Primary emphasis is on identifying the point source emissions of individual resources over the complementary principle of maximizing system impact, which necessitates counterfactual analysis.
  - This recommendation implies that 24/7 CFE accounting is based on the contractual obligations between the owners of individual resources and their customers.
- **Geographic deliverability.**
  - A 24/7 transition tariff should identify the market and geographic boundaries within which the utility will procure generation resources to match with customer load.
  - Deliverability is defined at the BA level. This is a large enough geographic area to encompass a diverse array of resources, and it benefits from an existing hourly, market-based accounting system. For the same reasons, it also enables imports from neighboring BAs.
  - Deliverability expressly excludes the use of carbon offsets because they are not part of the BA's market-based accounting system.
- **Fairness to nonparticipants.** Nonparticipating consumers should not be harmed by the implementation of 24/7 transition tariffs.

Additions, Modifications and Clarifications

In this subsection, we modify five of the aforementioned principles and recommendations and propose a new one.

- **Add "Aggregated supply matched to aggregated demand."**
  - This principle flows out of the fact that a balancing authority's fundamental function is to match aggregated supply to aggregated demand. Load-serving entities (LSEs) also follow this principle as they procure multiple

supply sources to meet the demands of multiple customers.[2]

- In the same way, LSEs that offer a 24/7 CFE product or tariff will be offering it to individual customers, with the intent to aggregate their demand and match it up to a portfolio of supplies. In other words, a 24/7 CFE offering creates a series of one-to-one obligations (LSE to customer) that are collectively met using a many-to-many relationship.
- This is an important principle because it makes clear that the nature of the service being offered is aggregated and does not imply that the LSE is serving an individual customer's load with 24/7 CFE.

- **Consolidate "Local procurement" into "Geographic deliverability."** These are close synonyms. The "geographic deliverability" label is intended to capture the essence of both.
- **Generalize and clarify the definition of "Enable new generation."**
  - "Enable new generation" is generalized to "Enabling of new resources," which captures both the demand and the supply side as well as storage.
  - The definition of "new" is clarified to include two components: the commercial operation date and the percentage of the 24/7 CFE portfolio that it constitutes. 24/7 CFE suppliers and their regulators are free to define "new" using a commercial operation date of their choosing, as long as it is disclosed along with the percentage of new 24/7 CFE that is being supplied.
- **Consolidate "Market-based accounting" into "Attributional accounting."** These two principles are closely related and complementary. As a result, they are being folded together.
- **Change "Maximize system impact" to "Measurable system impact."**
  - Although it is ideal to maximize system impact, we believe that the perfect should not stand in the way of progress. Thus, we would require only measurement, not maximization.
  - Consequential accounting can complement attributional accounting to estimate the emissions impact of the new CFE resources that are supporting the tariff or product offering.
- **Generalize "Fairness to nonparticipants" to "Fairness to all participants."** Fairness can be generalized to apply to participants and nonparticipants alike, and this principle can indicate that 24/7 CFE resources can have both costs and benefits.

After these modifications, eight principles remain and are listed in Table A-1.

Table A-1. Eight principles of 24/7 carbon-free electricity

Principles
1. Aggregated supply matched to aggregated demand
2. Time-matched procurement
3. Geographic deliverability
4. Technology neutrality
5. Enabling of new resources
6. Attributional market-based emissions accounting
7. Measurable system impact
8. Fairness to all participants

2 We use the term "load-serving entity" to include utilities in regulated jurisdictions and utilities and retail suppliers in restructured jurisdictions.

Eligibility Requirements

This section develops eligibility requirements for 24/7 CFE resources using the aforementioned principles as categories. With the exception of the first, each of these principles implies a series of high-level eligibility requirements that must be met for a resource to be included in a 24/7 transition tariff or product offering. For example, **time-matched procurement** requires hourly metering for both 24/7 CFE resources and the customer's load. Similarly, **geographic deliverability** requires that resources be delivered and settled in the same balancing authority as the load being served.

Although the first principle — that aggregated supply is matched to aggregated demand — does not imply eligibility requirements, it does suggest a requirement that existing resources be included in the baseline. A properly designed 24/7 transition tariff should enable the customer to understand and quantify the degree to which their energy usage is or would be matched with hourly clean energy without the pursuit of a special tariff or contract. By quantifying and communicating the load-ratio share of clean energy that a 24/7 transition tariff customer already receives, the regulator and policymaker will be able to determine how additive a customer-specific 24/7 CFE resource is to the system. In many market contexts, the incumbent utility will account for and retire the renewable energy certificates associated with the existing resources through state-level regulatory processes. In these instances, it would not be workable for the utility to transfer those renewable energy certificates to the customer. Rather the utility should pursue an accreditation accounting method for reporting.[3]

The **technology neutrality** principle is deliberately interpreted through a broad lens. As long as a resource has low or zero carbon emissions and it meets the other eligibility requirements, it is considered eligible. By creating a technology-inclusive framework we also empower local jurisdictions to adopt the specific criteria for technology eligibility that are best suited to their local policy objectives. Several resource categories deserve special attention with respect to this principle: aggregations; low-carbon resources such as biomass; carbon capture and sequestration; and storage.

- Aggregated resources. Aggregated resources such as virtual power plants may be eligible, as long as they are low or zero carbon. These resources may be from the demand or the supply side, and they may be tracked through demand-side load shaping and/or direct, supply-side metering. To avoid double counting, they must be disclosed and tracked hourly using the same tracking system as other 24/7 CFE resources.
- Low-carbon resources. Biomass resources are considered renewable in most jurisdictions, but they typically are not zero carbon. As long as the jurisdiction considers them eligible and they are disclosed and tracked using the same tracking system, they can be considered eligible.
- Carbon capture and sequestration. These resources may also be eligible, even if they don't reduce emissions to zero. As long as they are disclosed and tracked using the same tracking system, they can be considered eligible.
- Storage resources.
    - As a critical resource for 24/7 CFE, storage is eligible as long as it is charged with hourly matched CFE and uses a rigorous and well-documented accounting methodology, such as the one EnergyTag has been developing for

3 A good example is the Entergy Go ZERO tariff's use of "alternative energy credits."

a storage use case.[4] Importantly, this does not imply that the storage resource be charged with 24/7 CFE during all hours, only that charging and discharging energy be hourly matched with CFE for hours claimed.

- In addition, there need not be any physical requirement for co-location between the 24/7 CFE resource and the storage resource. For example, an LSE may have hourly matched solar production in its portfolio to provide the charging energy for a given hour. The solar need not be co-located with the storage.
- Similarly, a commercial contract between the 24/7 CFE resource providing the charging energy and the storage resource need not be present. The hourly matching requirement is sufficient to establish the linkage for 24/7 CFE claims.

The **enabling of new resources** principle is considered met if the transition tariff results in the development of a new or expanded 24/7 CFE resource. Qualifying resources may include expansions of existing 24/7 CFE resources and may be sourced from either the demand or the supply side. There is no minimum threshold for how much new, additional 24/7 CFE is included in the tariff. However, disclosure of such a percentage is a requirement. This ensures that both customers and regulators know to what extent this principle is being employed. Finally, allowing existing 24/7 CFE resources to be eligible under this principle also meets the technology neutrality principle.

The **attributional accounting** requirements are based on making a series of disclosures both mandatory and transparent to the customer. At a minimum, these must include the technology type, the source and sink settlement locations,[5] the owner, the contractual path to the customer, and the product(s) being conferred. In practice, the contractual path to the customer will most likely flow through the supplier's portfolio of 24/7 CFE resources, not from individual resources.

The product(s) being conferred is especially important, and the proposed eligibility requirements under attributional accounting allow for both energy that is bundled with time-stamped energy attribute certificates (EACs)[6] and EACs that are unbundled from energy. If unbundled certificates are used to support the product being offered, then disclosure of the percentage of unbundled certificates and the underlying resource(s) must be made. Hourly EACs should be used where available for 24/7 transition tariffs. Where these are not yet available, state regulators should take the necessary steps to ensure their rapid implementation following best practices and standards.

4 EnergyTag. (2024a). *Granular certificate scheme standard* (Version 2), pp. 25-30. https://energytag.org/wp-content/uploads/2023/09/Granular-Certificate-Scheme-Standard-V2.pdf

5 The source location is where the generator is located, and the sink location is where the load is located. Balancing authorities routinely track this information, and it is a boilerplate part of electricity supply contracts.

6 Time-stamped EACs are defined by building upon EnergyTag's definition of an EAC, which is, "A generic term for a unique transferable electronic record or guarantee created to provide to a consumer evidence of the characteristics of a specific unit of energy conveyed by an Energy Carrier and/or the method and quality of its production. Examples include a Guarantee of Origin (GO) or a Renewable Energy Certificate (REC)." EnergyTag. (2021). *EnergyTag and granular energy certificates: Accelerating the transition to 24/7 clean power,* p. 28. https://www.energytag.org/wp-content/uploads/2021/05/EnergyTag-and-granular-energy-certificates.pdf

The **measurable system impact** principle is considered met when the supplier discloses how much existing 24/7 CFE (not "new") is operating within the balancing authority and the volume of existing 24/7 CFE to which the customer is entitled. This disclosure forms a baseline of comparison for any consequential analysis that the supplier or customer may want to conduct.

Finally, **fairness to all participants** implies several requirements. First, the 24/7 transition tariff should be designed to net all costs and benefits for all participants. This includes direct costs and benefits to the electric system, such as energy, generation capacity, ancillary services, and deferred transmission and distribution investment. It can also include indirect costs such as the Supply Induced Price Effect and avoided health care costs. In practice, the netting may take place between so-called grid-integration costs on the one hand and the Supply Induced Price Effect and avoided health care costs on the other. For further discussion on this topic, see Appendix C on rate-making.

Another requirement is that the transition tariff allocate existing 24/7 CFE equitably. This could be done by allocating a pro rata volume of existing 24/7 CFE resources to both participants and nonparticipants alike. Alternatively, the utility or supplier could compensate (in dollars) nonparticipating customers for any net costs or benefits arising from the adoption of the 24/7 transition tariff.

This principle is not meant to ensure that the overall cost and emissions profile of the resources within the balancing authority remain unchanged. In fact, the addition of a 24/7 transition tariff will change the dispatch order and mix of resources in the system, which will impact the cost and/or carbon emissions for nonparticipants. Instead, the principle is directional. It points designers of 24/7 CFE products in the direction of quantifying all costs and benefits and allocating them as fairly as possible.

Table A-2 on the next page summarizes the requirements as they relate to each principle.

Table A-2. Summary of eligibility requirements for 24/7 CFE resources

Principle	Requirement
Aggregated supply matched to aggregated demand	• The nature of the service being offered is aggregated and does not imply that the LSE is serving an individual customer's load with an individualized portfolio of 24/7 CFE supplies. • 24/7 transition tariffs create a series of one-to-one obligations (LSE to customer) that are collectively met using a many-to-many relationship.
Time-matched procurement	• Must be metered and reported in at least hourly increments that match up to the time increments being used to meter the customer's load. • Where hourly metering is not yet available, representative load and generation profiles may be used.
Geographic deliverability	• Must be delivered to and settled in the same balancing authority as the load being served.
Technology neutrality	• Must be a low- or zero-carbon-emitting resource. Resources that may be eligible include aggregations, biomass, carbon capture and sequestration, geothermal and imports. • Storage resources must be charged with hourly matched CFE and use a rigorous and well-documented accounting methodology. • May include resources from both the supply and the demand sides.
Enabling of new resources	• Must be made up of newly constructed 24/7 CFE resource(s) or a combination of existing and new 24/7 CFE resources. • Must disclose the percentage of new 24/7 CFE resources that are included in the tariff or product offering.
Attributional market-based emissions accounting	• Must disclose the resource owner and the contractual path to the customer and their supplier. • Must disclose the product(s) being conferred to the customer and the resource-specific characteristics that support it using hourly EACs for disclosure where available. • Must disclose the percentage of hourly EACs, or the best proxy thereof, and identify the underlying resource(s) backing them.

Measurable system impact	• Suppliers must disclose:
	  ◦ How much existing 24/7 CFE (not "new") is operating within the balancing authority.
	  ◦ The volume of existing 24/7 CFE to which a customer is entitled.
	• This disclosure forms a baseline of comparison for any consequential analysis that the supplier or customer may want to conduct.

Fairness to all participants	• The 24/7 transition tariff should be designed to net all costs and benefits for all participants. • The 24/7 transition tariff should allocate existing 24/7 CFE equitably between participants and nonparticipants.

Eligible Technologies

Table A-3 lists the technologies that could be eligible for a 24/7 transition tariff. Importantly, it deliberately makes no distinction between new and existing resources because the disclosures that are required under the principle of enabling new resources make the mix of existing and new resources plain.

The table includes a list of 10 technology categories and a series of sample resources in each category. The list is meant to be comprehensive at the level of the categories, but it is deliberately incomplete with respect to the sample resources that are listed. For the sake of brevity, the sample resources column for aggregations, storage and imports is left incomplete, and we acknowledge that some examples of these resources are left out of the table. To the extent a jurisdiction declares a carbon-emitting resource to be "eligible" during the transition period toward 100% carbon-free electricity, that jurisdiction must acknowledge, measure and disclose hourly carbon emissions associated with that resource so that all emissions are transparent.

Three categories of resources deserve more explanation.

Aggregations of carbon-free distributed energy resources may include any 24/7 CFE resource that is interconnected at the distribution level. This includes resources that are behind the customer's retail consumption meter, as long as they are measurable and controllable at the balancing authority level under FERC Order 2222. Such resources may commonly include solar, battery storage and demand response programs that control appliances such as electric water heaters and thermostats. Legacy programs for interruptible load control and demand response may also be included, as long as they are controlling aggregations of 24/7 CFE resources.

Table A-3. Eligible resources

Category	Sample resources
Aggregations	• 24/7 CFE distributed energy resources
Biopower	• Biomass, digesters • Municipal solid waste
Carbon capture and sequestration	• Carbon capture and sequestration
Geothermal	• Geothermal
Hydropower	• Large hydropower • Small run of river
24/7 CFE imports	• Transmission
Nuclear	• Conventional • Small modular reactors
Solar	• Concentrating • Photovoltaic
24/7 CFE from storage, and storage plus other resources	• Battery • Battery + solar • Compressed air • High-temperature thermal • Hydrogen — clean • Pumped hydropower
Wind	• Offshore • Onshore

Imports are expected to be an increasingly significant source of 24/7 CFE resources in the future, and they do qualify under the proposed eligibility requirements. Neighboring balancing authorities already trade electricity during times of surplus or deficiency, and an existing North American Electric Reliability Council standard, *Evaluation of Interchange Transactions*,[7] already requires that both the LSE and the BA have the capability to electronically verify (and time-stamp) both the generation source and the load sink of such transactions. As a result, this standard is compatible with 24/7 CFE's hourly matching requirements, and it enables LSEs to include imported 24/7 CFE into their products.

Finally, there are a variety of **storage** resources and the potential for combinations of storage with other 24/7 CFE resources. The most common example presently is battery storage combined with solar, but other combinations will surely surface. In all cases, storage resources must utilize 24/7 CFE resources during the charging cycle, account for losses and be time-matched with load during the discharging cycle.

Each of these resource categories can provide a series of services to the grid. There are four broad types of grid services that can be provided, and the degree to which they can be delivered will vary based on the nature of the technology, the location of the resource and conditions on the grid at the time those services are needed.

- **Energy.**
  - Delivered at specific locations and points in time.
  - All resources are capable of providing energy.
- **Generation capacity.**
  - To provide energy when it is needed most.
  - Both dispatchable and intermittent resources can provide generation capacity.
- **Transmission and distribution capacity (deferred).**
  - To enable delivery of energy when and where it is most needed.
  - Sources of transmission and distribution capacity services can include resources behind the customer's meter and storage, which can defer the need for investments.
- **Reliability services.**
  - Including operating reserves, regulation reserves, frequency response, voltage regulation and black start capabilities.

Data Requirements

The data requirements for 24/7 CFE and non-CFE resources are expected to be different. The next two subsections address each type of resource separately.

24/7 CFE Resource Data Requirements

Data requirements for 24/7 CFE resources flow naturally out of the choice to follow attributional, market-based accounting procedures. These requirements include the data elements that are routinely captured with the information technology systems of distribution utilities, their balancing authorities and/or the load-serving entities. In regions with generation or emissions tracking systems, much of the same information may be sourced from within those organizations. Table A-4 on the next page summarizes the requirements in the language that is often used in commercial term sheets.

This list is intended to be comprehensive, and many of the requirements are self-explanatory. However, the line losses and baseline 24/7 CFE volume categories deserve more explanation, as does the implementation of the systems that enable and make use of this data.

7 North American Electric Reliability Council. (n.d.). *Evaluation of interchange transactions* (Report INT-0006-5). https://www.nerc.com/pa/Stand/Reliability%20Standards/INT-006-5.pdf

Table A-4. Data requirements

Category	Data element	Source organization(s)
Administration	Relevant balancing authority (BA) Relevant distribution utility (DU) Emissions tracking system(s) in use	Load-serving entity (LSE) LSE LSE
Customer characteristics	Premises ID Customer name and address Meter ID(s)	DU DU, LSE DU
Losses	Distribution line losses Storage losses Transmission line losses	DU LSE BA
Location	Balancing authority Source location Sink location	LSE LSE LSE
Ownership	Buyer name Seller name	LSE LSE
Resource characteristics	Baseline 24/7 CFE volumes (BA level) Baseline 24/7 CFE volumes (LSE level) Emissions by hour Resource name/ID Product(s) Technology type	BA, LSE LSE LSE LSE LSE LSE
Time	Commercial operation date Metering interval Begin date and time End date and time	LSE LSE LSE LSE
Volumes	Delivered 24/7 CFE quantity 24/7 CFE portfolio purchases/sales Customer usage	BA, DU BA, LSE DU, LSE
Other		

First, measuring line losses is essential because they are incurred to deliver 24/7 CFE from the generator to the customer. As a result, line losses must be accounted for during the time-matched procurement process. Line losses do vary hourly and by location, and are sometimes measured hourly. However, they are known to be difficult to calculate generally. As a result, a methodology for calculating and attributing line losses to 24/7 CFE customers must be made transparent in the 24/7 transition tariff.

Second, these data requirements include two items concerning baseline 24/7 CFE volumes, one at the grid level and one at the LSE level. These data requirements have two different purposes. The grid-level requirement enables consequential accounting to take place, while the LSE-level requirement enables the principle of fairness to all participants to be acted upon.

Finally, implementing systems that capture and use this information is beyond the scope of this paper, but it will be critically important to avoid double counting. Fortunately, EnergyTag's *Granular Certificate Scheme Standard*[8] and *Granular Certificate Use Case Guidelines*[9] discuss implementation standards and options in detail for hourly energy attribute certificates — what it calls granular certificates. Specifically, the *Granular Certificate Scheme Standard* "provides a framework to allow market participants to voluntarily obtain [granular certificates] and enable consumer choice, while ensuring smooth interaction with existing EAC Schemes and avoiding Double Counting." As a result, we defer to EnergyTag's work for standard-making and implementation purposes.

Non-24/7 CFE Resource Data Requirements

Products that guarantee 100% CFE in every hour are not yet a commercial reality. As a result, emitting resources must be accounted for and reported on to determine both the emissions profile for customers who subscribe to a 24/7 transition tariff and how this profile would compare to the standard or "bundled" tariff option. This information is also needed by customers that are not participating in the tariff. A discussion of these issues appears in Appendix B.

Recommendations

Integrated planning in support of public interest outcomes has been important for decades. The drive toward full decarbonization of the power, buildings and transportation sectors has elevated integrated planning once more.

Accelerating progress toward decarbonization with 24/7 transition tariffs requires that resource, data and infrastructure needs come together in an integrated fashion. This section provides high-level recommendations for effectively integrating 24/7 CFE portfolios with ongoing planning processes.

RECOMMENDATION 1:

Recognize that 24/7 carbon-free electricity contributes to policy goals.

- Local, state, federal and utility policy goals are already driving grid and resource investments to support cleaner energy portfolios. Because 24/7 transition tariffs will result in more clean energy on the grid, they should be recognized as being inherently complementary to these goals. The incremental carbon reductions caused by 24/7 CFE should therefore be reflected in cost-benefit evaluations.

---

8 EnergyTag. 2024a.

9 EnergyTag. (2024b). *Granular certificate use case guidelines* (Version 2). https://energytag.org/wp-content/uploads/2023/09/Granular-Certificate-Use-Case-Guidelines-V2.pdf

RECOMMENDATION 2:

Follow the eight 24/7 carbon-free electricity principles.

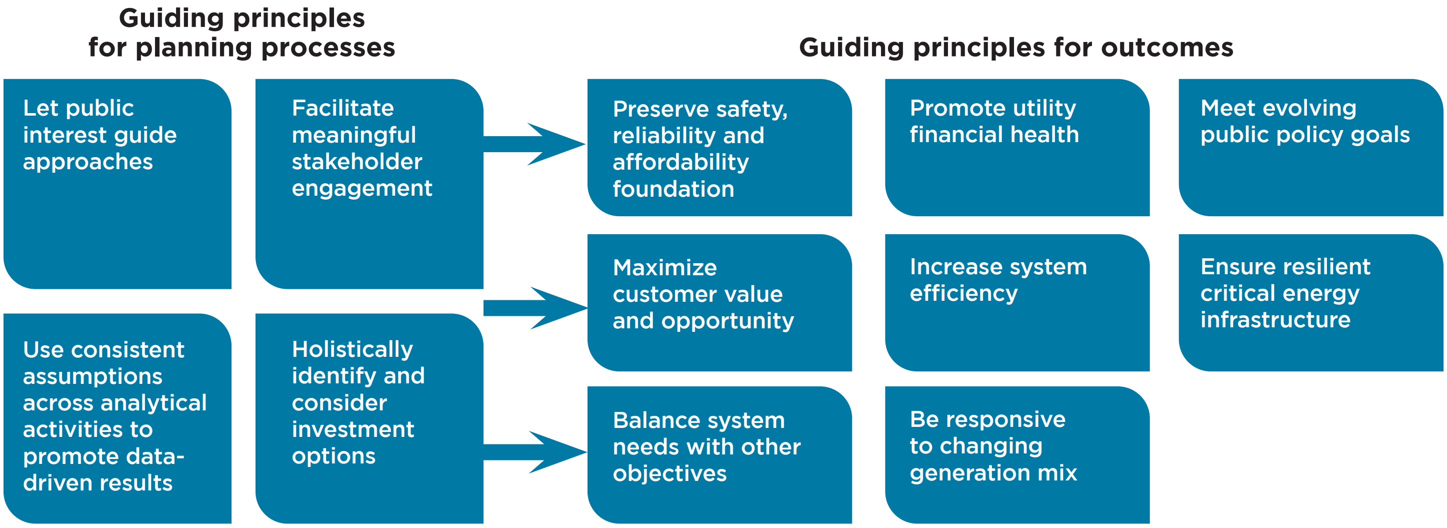
- The principles of 24/7 CFE outlined in this appendix are rooted in the collaborative stakeholder processes from both this project and the 24/7 Carbon-Free Energy Compact. As a result, they represent a well-considered set of guideposts that can guide 24/7 transition tariff development.

RECOMMENDATION 3:

Use comprehensive planning principles.

- The NARUC-NASEO Task Force on Comprehensive Electricity Planning completed best practice planning roadmaps for several distinct regulatory and market contexts. The task force identified guiding principles that should be incorporated into planning processes to achieve public interest outcomes (see Figure A-1).[10] The task force applied these recommendations within several different contexts by establishing six cohorts (see Figure A-2 on the next page), each of which was aligned with a distinct context.[11] We recommend that LSEs consult these contexts and apply the comprehensive planning principles when designing their 24/7 CFE portfolios. This will ensure that the broader public interest is considered throughout the planning process and is ultimately reflected in the 24/7 transition tariff itself.

Figure A-1. Principles for planning processes and outcomes

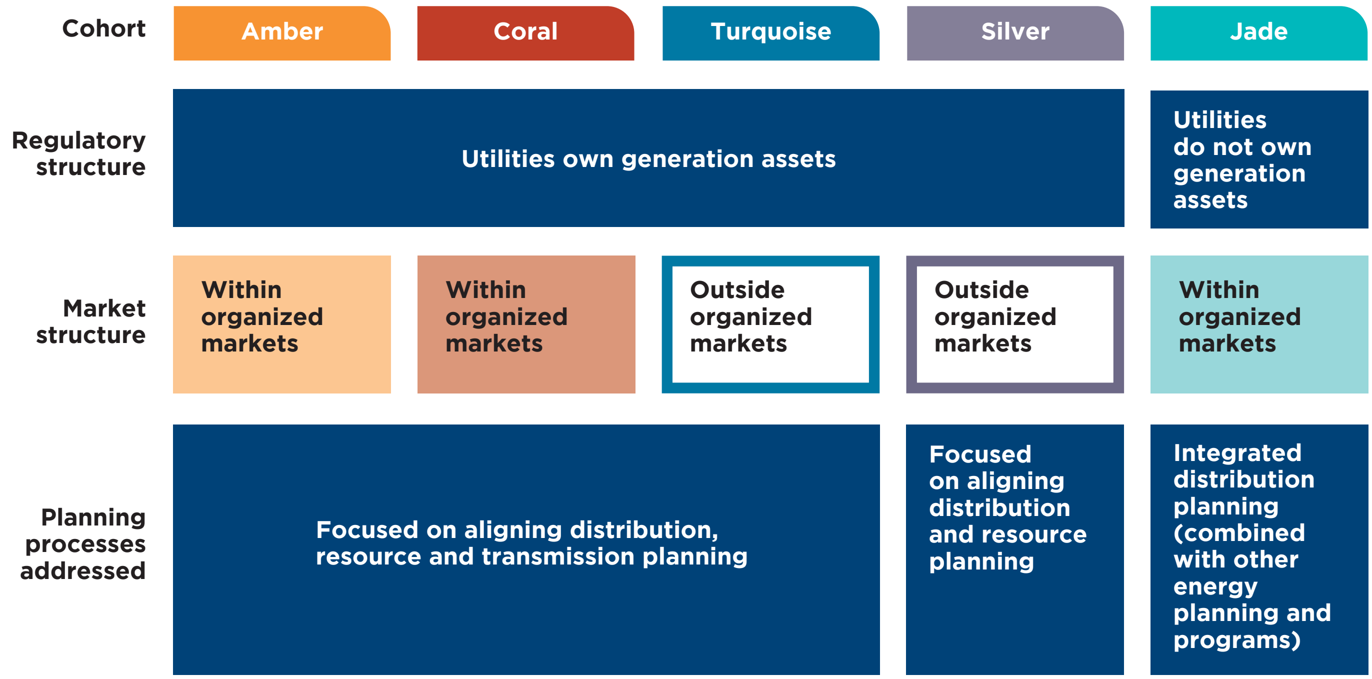


Source: NARUC-NASEO Task Force on Comprehensive Electricity Planning. (2021, February). *Blueprint for State Action*

10 NARUC-NASEO Task Force on Comprehensive Electricity Planning. (2021, February). *Blueprint for state action*, p. 15. National Association of Regulatory Utility Commissioners, National Association of State Energy Officials. https://pubs.naruc.org/pub/14F19AC8-155D-0A36-311F-4002BC140969

11 NARUC-NASEO Task Force on Comprehensive Electricity Planning, 2021, p. 9.

Figure A-2. NARUC-NASEO planning task force cohorts and contexts



Source: NARUC-NASEO Task Force on Comprehensive Electricity Planning. (2021, February). *Blueprint for State Action*

RECOMMENDATION 4:

Use both emissions accounting methods during planning.

- As Appendix B on emissions tracking and verification will make clear, measuring and validating emissions requires attributional, bottom-up accounting from the LSE's perspective. However, it is also necessary to simultaneously consider consequential progress toward aggregate emissions reduction from the top-down perspective of the balancing authority. Integrated planning can use both methods to illustrate how 24/7 transition tariffs impact the emissions of the LSE's supply portfolio as well as the emissions on the balancing authority's grid.

Appendix B: Emissions Tracking and Verification

Lead author: David Farnsworth

For customers of load-serving entities (LSEs) to be able to match their hourly energy use with attributes of hourly energy production delivered, or capable of being delivered, into their balancing authority requires certain systems to be in place — systems that ideally use available emissions and load data.[1] Some of those systems exist today. However, they have yet to realize their full potential.

What follows is a look at the challenges associated with matching hourly energy production with hourly energy use, starting with an ideal solution: a standardized, national, all-generation hourly tracking system that can be matched with customer energy use data. We discuss related standards that can improve existing energy attribute tracking systems around the country. We also walk through key issues and articulate best practices that can lead to standards that need to be adopted and harmonized across the country.

Emissions Data and Energy Resource Tracking Systems To Enable 24/7 Procurement

RECOMMENDATION 1:

States and load-serving entities should support the adoption of nationwide standards for hourly all-generation tracking systems.[2]

RECOMMENDATION 2:

Where a single all-generation tracking system is not available, states should require the adoption of, and LSEs should adopt, a system to:

a. Support hourly tracking and the issuance of hourly certificates.

b. Implement best practices that could become a national standard for hourly reporting of fossil generation emissions data, starting with, for example, publicly available data from continuous emissions monitoring systems (CEMS) reported to the U.S. Environmental Protection Agency

1 We use the term "load-serving entity" to include utilities in regulated jurisdictions and utilities and retail suppliers in restructured jurisdictions.

2 As a complement, states and load-serving entities should also support the development and adoption of nationwide standards for the provision of customer hourly energy use consistent with the discussion of "Customer Load Data" below.

(EPA) for generation resources with capacity of at least 25 MW, and generator-specific heat rate data for resources smaller than 25 MW.

c. Provide the best available customer load data in a standard format to ensure hourly matching.

A national all-generation tracking system would be the ideal platform to meet the accounting and tracking requirements needed for a 24/7 transition tariff. Such a system could keep track of hourly CFE production and hourly non-CFE production, and then produce corresponding hourly energy attribute certificates (EACs) for utilities to match with customer energy use.

A single all-generation tracking system would ideally track the transaction of hourly CFE certificates but would also track hourly certificates that are retired without having been traded. Grouped together, this latter category of EACs would constitute the "residual mix" on a system.

In reality, of course, the U.S. has no one system capable of doing this. There are various tracking systems, several of which have different all-generation tracking capabilities, while others simply track renewable resources. This presents an obvious challenge for the broad adoption of 24/7 CFE because these systems are not necessarily interoperable, and they need to be.

Perhaps a more realistic approach, one that has been adopted in Europe, would be for existing tracking systems to meet the same standards and follow similar practices.[3] We recommend that states require a more uniform approach to the issuance, tracking and retirement of hourly CFE certificates and the adherence to the recommendations outlined in this appendix.

While no systems in the U.S. have yet been developed with the ability to track, match and support transactions with hourly certificates, Entergy Arkansas and M-RETS have partially developed this capability. They do not have an all-generation tracking system, but they are beginning to track existing hourly CFE (along the lines of Recommendation 2a above).[4] With the support of M-RETS (which tracks CFE and creates corresponding hourly certificates) and third-party verification by the Green-e Energy program,[5] a customer like the U.S. government can account for its fair share of allocated CFE purchases included in rate-base generation and retire hourly certificates to reflect that share.[6] With this tracking capability, an Entergy customer can establish its "24/7 CFE baseline" — that is, the percentage of CFE in its hourly energy use.[7] From there, it can add to its existing share of CFE and build toward 100% hourly CFE by purchasing incremental CFE.

3 The European Union allows member states to have their own tracking system, but each system must work within the Association of Issuing Bodies framework. This framework contains common standards for all tracking systems — for example, the requirement that they audit each other annually for compliance and accountability purposes. Association of Issuing Bodies. (n.d.). *AIB guaranteeing the origin of European energy*. https://www.aib-net.org/

4 M-RETS. (n.d.). *Welcome to M-RETS*. https://www.mrets.org/. M-RETS does not yet produce certificates that can be traded separately. Hourly data can be viewed within monthly certificates. The retirement function remains within monthly certificates, so monthly certificates with hourly data can be retired to support hourly matching claims. See: Terada, R. (2023). *Readiness for hourly: U.S. renewable energy tracking systems*, pp. 26-28. Center for Resource Studies. https://resource-solutions.org/document/061523/

5 Green-e Energy is a certification program for voluntary renewables procurement. Center for Resource Solutions. (n.d.). *Green-e® energy*. https://www.green-e.org/programs/energy

6 Third-party certification is a critical aspect of ensuring product credibility and consistency across the market. It also provides a clear indication to consumers considering the tariff as to whether it meets national standards and practices. National standards also help provide consistency in application and practice across the U.S. market.

7 While the U.S. government accounts for its fair share of allocated 24/7 CFE purchases included in rate-base generation and contracted generation in Entergy Arkansas — a vertically integrated utility company — the U.S. government has also developed instructions to apply a similar approach in restructured markets. See: Mayock, A. (2023, August 4). *Clarification of grid-supplied carbon pollution-free electricity calculation methodology* [Memo]. White House Council on Environmental Quality. https://www.sustainability.gov/pdfs/grid-supplied-cfe-memo.pdf

Where energy use at specific hours is not matched with CFE, then that energy should be assumed to be fossil generated.[8] This hourly energy production also needs to be tracked to demonstrate to consumers the hourly resource mix and emissions rates associated with delivered resources. Ideally, an hourly all-generation tracking system would track and produce hourly certificates for non-CFE, as well.[9]

For emissions data — that is, the data that would be used to populate the emissions information on hourly certificates — we recommend using a combination of publicly reported data (the EPA's CEMS data) for fossil-fueled resources 25 MW and larger, and data calculated based on specific generator attributes (i.e., plant-specific emissions rates) for fossil resources that are smaller than 25 MW. Where this data is not available, we suggest alternative data sources.[10]

The Entergy Arkansas example is also noteworthy for another reason. The utility has demonstrated both the capability and willingness to make U.S. government energy use data available for purposes of enabling 24/7 CFE accounting. This, of course, is the other critical half of matching supply with energy use and is discussed further below.

Emissions Accounting

RECOMMENDATION:

Ensure that 24/7 CFE emissions accounting can support tariff design and the planning that will inform a decision to adopt a 24/7 transition tariff.

RAP's inquiry into developing a tariff for 24/7 CFE has made it clear that not only are we developing recommendations for a tariff design, but also principles that will shape the planning necessary to inform any decision to adopt a 24/7 transition tariff. For this reason, we need approaches to emissions accounting suited to both tasks.

To implement the procurement decisions that would support a 24/7 transition tariff fairly, it is necessary to have a planning process to help that happen. For example, with utility programs there is always a challenge in allocating costs and benefits, and this raises questions. Will entering into a 24/7 transition tariff produce costs for some? Will it create benefits for others? What effects will new load have on the power grid, the need for new supply and the timeline for retirements of existing generation? It is difficult to evaluate such questions without engaging in some form of planning exercise that develops a counterfactual, "compared to what?" analysis.

In other words, a planning exercise will help explain both how things might work with a 24/7 transition tariff in place (including certain assumptions about participation) and how things might work without it. Planning allows decision-makers to compare the investments that the tariff causes and the

8 This would be a conservative assumption regarding emissions. If an hourly, all-generation tracking system were available, then hourly load not matched with contracted 24/7 CFE would be assigned an hourly residual mix (i.e., the mix of all unclaimed certificates calculated in a tracking system), which may not be entirely fossil-fueled resources.

9 Residual mix would be composed of these certificates (i.e., EACs for non-24/7 CFE resources that are not transacted for and retired).

10 For further discussion, see the section "A Hierarchy of Preferred Approaches for Assigning Emissions to Generation" below.

investments that are avoided. It will also allow a comparison of the benefits that the investments produce and the costs that the adoption of a 24/7 transition tariff would create.

Consequential emissions accounting is a method for modeling how environmental impacts — in this case, emissions impacts on the grid — would change in response to a certain action or intervention, such as the development of a 24/7 tariff.[11] For example, this analysis could illustrate for decision-makers the effects of new load on existing resources and whether and what amount of new CFE will need to be developed in response.[12] Consequential accounting is well suited to illuminating these types of planning questions.[13]

Market-based, attributional accounting, on the other hand, is suited to supporting a tariff design because it establishes "inventories of emissions and removals within a defined inventory boundary,"[14] such as the portfolio of generation resources that an LSE would assemble to meet customer needs under a 24/7 transition tariff. It can be used to accurately track progress toward matching CFE and non-CFE purchases with the timing and location of consumption. And market-based accounting spotlights the resource decisions that are in the hands of the load-serving entity assembling the generation portfolio supporting the tariff. Furthermore, because an LSE is commercially engaged with these generation resources to meet its service obligations, market-based accounting also increases the likelihood of an LSE's ability to access relevant emissions data.

As noted above, identifying the emissions associated with resources procured for an hourly 24/7 tariff requires accounting for both the CFE that an LSE acquires and the carbon intensity of the other energy it uses to serve that customer. As already noted, market-based attributional accounting can partly rely on the EPA's reported data and on data calculations from generators smaller than 25 MW. This data availability hierarchy is discussed further below.

To summarize, for purposes of understanding the emissions implications of 24/7 transition tariff adoption, both consequential and attributional accounting are important.[15] Attributional accounting becomes critical in the immediate context of the tariff and in being able to use more-granular time and location data to characterize the direct carbon characteristics of customer energy use. Likewise, some kind of consequential analysis will need to be integrated into the planning efforts necessary to illustrate the likely emissions effects of various 24/7 tariff adoption scenarios and the potential results of adopting or not adopting such a tariff.

---

11 Brander, M. (2022). The most important GHG accounting concept you may not have heard of: the attributional-consequential distinction. *Carbon Management*, 13(1), 337-339. https://doi.org/10.1080/17583004.2022.2088402

12 For further discussion of planning and characterizing the effectiveness of transition tariffs on overall grid composition and emissions, see: Center for Resource Solutions. (2022, November). *Guide to electricity sector greenhouse gas emissions totals.* https://resource-solutions.org/document/110322/

13 Consequential accounting can establish and quantify a "causal relationship between an energy management or procurement decision and a change in indirect emissions from the power sector, relative to a counterfactual baseline in which the intervention did not occur." Miller, G. (2022). *Applying the consequential emissions framework for emissions-optimized decision-making for energy procurement and management*, p. 5. Clean Energy Buyers Institute. https://cebi.org/wp-content/uploads/2022/11/Applying-The-Consequential-Emissions-Framework-For-Emissions-Optimized-Decision-Making-For-Energy-Procurement-And-Management.pdf

14 Brander, 2022.

15 Ballentine, R., Falwell, P., Biasucci, L., & Fisher, N. (2022, August). *Modernizing how electricity buyers account and are recognized for decarbonization impact and climate leadership*, pp. 34, 36 and 39-40. Clean Air Task Force. https://www.catf.us/resource/modernizing-how-electricity-buyers-account-recognized-decarbonization-impact-climate-leadership/; and International Energy Agency. (2022, November). *Advancing decarbonisation through clean electricity procurement*, pp. 12-14, 59 and 73. https://www.iea.org/reports/advancing-decarbonisation-through-clean-electricity-procurement. See also Brander, 2022.

Customer Load Data

RECOMMENDATION 1:

If metered load data exists, a load-serving entity should:

a. Develop its 24/7 transition tariff based on that hourly data.

b. Provide customers with their hourly data in a standardized format to allow the customer to track and verify their own 24/7 CFE needs.

RECOMMENDATION 2:

If metered data does not exist, a load-serving entity can develop a customer load profile for the same purposes by disaggregating a customer's monthly usage into estimated hourly demand.

For a successful 24/7 transition tariff, LSEs will need to be able to match customers' hourly energy use data with hourly CFE and non-CFE generation data. Ideally, customers who sign up for such a tariff would have access to metered hourly usage data. This consumption could then be matched on an hourly basis with customers' CFE and non-CFE supply. Providing this data in a standard format would ensure that customers and other stakeholders are able to track and verify the percentage of CFE they have acquired. This will also contribute to the adoption of broader national standards for data provision.

While having advanced meters would make it easier to provide hourly customer load data, even where such meters are not available it is still possible to get a monthly meter read and allocate it to an hourly level.[16] For example, in some states where retail choice exists and advanced metering is not yet available, LSE load profiles currently are applied to monthly meter data to establish hourly supply obligations for customers, and these could serve as a basis for 24/7 CFE procurement.[17] When advanced metering is introduced, the second-best approaches based on monthly load profiles should be replaced by the more precise hourly approach.

Adopting Geographic Market Boundaries

RECOMMENDATION:

Define geographic market boundaries based on energy delivered, or capable of being delivered, into one's local service area.

RAP's 24/7 CFE inquiry has highlighted competing approaches for tracking energy production within a defined market boundary and the value in moving from a tracking system with broad market boundaries to one that better reflects physical deliverability of electricity.[18]

The first approach is represented by the Greenhouse Gas Protocol's Scope 2 guidance, an important framework for understanding and driving voluntary renewables markets, that allows for resources to be procured from anywhere in the U.S.[19] It currently provides limited direction regarding submarket geographic limitations on resource procurement. Under the current Scope 2 approach, renewable resources are broadly available, and the accepted practice has been for

16 Customers can be grouped according to the general characteristics of their usage and a load profile for each customer class is determined (typically through a "load study" using statistical methods). Weston, F., & Lazar, J. (2002). *Framing paper #3: Metering and retail pricing*, pp. 16-18. New England Demand Response Initiative. http://nedri.raabassociates.org/Articles/NEDRIpaper3final.doc

17 Personal communication, Neil Fisher, July 14, 2023.

18 The geographic market boundary defines the area from which certificates can be purchased and claimed for a buyer's Scope 2 market-based accounting and reporting.

19 Sotos, M. (2015). *GHG protocol scope 2 guidance.* World Resources Institute. https://ghgprotocol.org/scope-2-guidance

renewable energy certificates to represent the contractual choices consumers make for how their renewable power is generated within the same market.[20] While that is an established practice for purposes of voluntary renewables procurement, and while a "larger market boundary for certificate use promotes broader areas of consumer choice,"[21] one of the important questions being considered as part of the protocol's ongoing revision process is how to account for the consumption of energy based not just on *when* it is produced but *where* it is produced.[22]

The alternative approach can be described as being based on "physical delivery." While this approach is consistent with practices in power markets, it is important to recognize that physical delivery is also an artificial construct and way of talking about tracking energy production.

The laws of physics that apply to alternating current electric system operations tell us that it is very difficult to physically direct the energy produced by a generation resource to a specific customer.[23] The power grid is filled with electric energy produced by multiple resources that all feed into the grid, and the grid is a lot like a reservoir that gets filled from different sources such as rivers, streams, groundwater and rain. The concept of "deliverability" is a financial convention used in this context to ensure that producers and buyers can connect and engage in transactions for the purchase and sale of the electric energy withdrawn from the grid.

Energy delivered, or capable of being delivered, into one's balancing authority is often the basis for a transaction.[24] A generator produces electricity that is metered. Being able to demonstrate the ownership of that amount of energy, the generator in a restructured market typically will sell it to an intermediary, who, in turn, sells the energy to a retail LSE that will use it as part of its supply portfolio for its customers. Buyer and seller define the property interest, where it is located, where it is to be delivered and related terms. Included in the transaction is the recognition that the energy itself comes at a cost, and depending on grid conditions, transmitting that energy may also create costs.[25] Despite being a convention, deliverability is a key part of energy transactions. It is also important in voluntary clean energy markets to ensure public confidence in these practices and claims.

While this discussion centers on carbon, it is also important to remember that renewable energy certificates or other energy attribute certificates typically reflect all the environmental attributes associated with the unit of energy produced by a clean resource. This can mean not only carbon but also avoided criteria pollutants like oxides of nitrogen and particulate matter. To the degree that resources are subject to some physical delivery requirement, then the environmental attributes associated with these more local resources are more likely to produce tangible pollution reduction benefits.

20 "Despite differences in state law, local regulatory policy, and variation in physical interconnection within these regions, the entire United States is considered a single market for use of EACs." Sotos, 2015, p. 65.

21 Sotos, 2015, p. 64.

22 Miller, G., Pease, G., & Shi, W. (2023, August). *Where matters: Integrating deliverability into voluntary clean energy market boundaries* (Executive summary). Singularity Energy and The Brattle Group. https://singularity.energy/deliverability-download-page

23 While it is not possible to "direct" energy to a specific customer, technically speaking, identifying the origin of specific electrons through power flow and proportional sharing analysis is possible. See: Chen, X., Chao, H., Shi, W., & Li, N. (2023, August). *Towards carbon-free electricity: A comprehensive flow-based framework for power grid carbon accounting and decarbonization*. arXiv. https://arxiv.org/pdf/2308.03268.pdf

24 Geographic limitations for bundled electricity products have been developed by the Center for Resource Solutions in its Green-e Energy program. See: Center for Resource Solutions. (2024). *Green-e® renewable energy standard for Canada and the United States* (Version 4.3), Section IV.A, p. 17. https://www.green-e.org/docs/energy/Green-e%20Standard%20US.pdf

25 In a vertically integrated utility context, these steps would occur all within the confines of one company.

In developing 24/7 transition tariffs, decision-makers will need to balance practicality with the potential benefits and costs of better aligning the tracking of 24/7 CFE resources serving consumption with the physical realities of the grid. Defining deliverability at the balancing authority level is a credible place to start and would build on current energy market practices.

Fairness Considerations

RECOMMENDATION:

Where states and load-serving entities are reviewing the appropriate allocation of existing carbon-free electricity in an LSE's resource mix to customers under a 24/7 transition tariff, states can promote decarbonization and ensure that participating and nonparticipating consumers are treated fairly.

It is important to support first movers in this context, but also to ensure that nonparticipants are not harmed by the development of 24/7 transition tariffs. For example, on a first-come, first-served basis, a customer seeking to procure existing CFE in a load-serving entity's service territory could conceivably acquire as much CFE as needed to cover all of the customer's energy use.

In existing voluntary markets, it is common to design voluntary products to support generation resources that are surplus to resources developed in response to regulation. Existing CFE, however, has likely been developed using, among other revenue sources, ratepayer dollars. Giving credit to a 24/7 transition tariff customer for more than what that customer is historically responsible for supporting would deprive remaining ratepayers of the benefit of the resources for which they have already paid in rates. Observing this rule is important for both existing and new customers seeking to procure CFE. An allocation decision rule that recognizes the need for accurate crediting will promote fairness by preserving existing CFE and non-CFE allocations. Preserving the status quo allocation will also serve to advance decarbonization by stimulating the development of incremental CFE to meet incremental demand.

The Entergy Arkansas 24/7 tariff (designed on behalf of the federal government and other customers) serves as a useful example of fairness in allocating existing CFE resources.[26] The current resource mix in Entergy Arkansas' service territory is roughly 70% CFE and 30% non-CFE. Customers on the tariff will be assigned the same proportions of CFE and non-CFE as they would be entitled to even if they weren't seeking to procure and account for CFE.[27] This ensures that nonparticipating Entergy Arkansas ratepayers continue to benefit from the existing resource mix that their rates helped to develop.

As noted in the emissions accounting discussion above, absent planning and modeling it is difficult to know with any clarity what benefits and costs to expect from a decision to adopt a 24/7 transition tariff. Planning and modeling help identify, for example, the consequential effects of existing load claiming more CFE than what it has historically supported or new load seeking to acquire existing CFE. To ensure fairness to all ratepayers, and to promote the development of new CFE resources, it is critical to be able to understand and then allocate the costs and benefits of adopting a 24/7 tariff.

26 This observation applies to grid-supplied 24/7 CFE, meaning utility-owned generation and purchased generation, but excluding privately claimed generation in the utility's territory.

27 The U.S. government clarified that in vertically integrated utility markets, grid-supplied 24/7 CFE should not exceed on a percentage basis what the federal consumer would have otherwise received as part of the standard offer service. See Mayock, 2023.

A Hierarchy of Preferred Approaches for Assigning Emissions to Generation

RECOMMENDATION:

Rely on the best available reported and calculated emissions data to populate energy attribute certificates.

Load-serving entities (or their electricity suppliers) that offer 24/7 transition tariffs should support hourly CFE tracking and the issuance of hourly CFE certificates that can be retired on behalf of customers served on the retail tariff. There are different data sources for fossil-generation emissions that can be used to populate hourly CFE energy attribute certificates. Some data is reported while other data needs to be calculated.

Reported Data

Continuous emissions monitoring systems data is generally derived from fossil-fueled units 25 MW or larger. CEMS data is measured hourly and reflects any fuel being used at a facility. This is publicly available data that is reported quarterly, with a one- to four-month lag before the data is made public.

Data Calculation Methods

Emissions data can be calculated using a generator-specific heat rate in combination with an emissions factor for fuel used by an emissions source. Fuel data, however, is sometimes considered confidential.

In the alternative, emissions data can be calculated using a generator-specific historic heat rate or a generator-specific average heat rate. These methods are accurate, even with multifuel generators, and can be readily calculated if fuel-specific information is available.

Another alternative is to calculate emissions with monthly historic heat rates. Plants that do not report hourly data to CEMs do report monthly fuel consumption and heat rate data to the Energy Information Administration using Form-923. While not as robust as CEMS data or data derived using generator-specific heat rates, Form-923 data can be used to characterize emissions for specific generators.

Other calculation methods based on generator-type average heat rates are available from the EPA's eGRID database[28] or other open sources of data, such as Singularity's Open Grid Emissions database.[29] This data, however, becomes available with a considerable time lag.[30]

The least accurate calculation method would be to use a default regional and technology-conservative fuel-specific emissions factor. For example, this approach would identify a simple cycle gas plant as producing X amount of carbon dioxide per kWh in a particular regional transmission organization.

28 U.S. Environmental Protection Agency. (2024, January 30). *Emissions & generation resource integrated database (eGRID).* https://www.epa.gov/egrid

29 Singularity. (n.d.). *Open grid emissions* [Dataset]. https://singularity.energy/open-grid-emissions

30 Some commenters have noted that, while some time lag should be expected for validation purposes, it is possible to reduce this time lag by, for example, developing "prevalidation" estimates that may be acceptable in certain contexts.

In assessing which source(s) of emissions data to rely upon, states should first recognize the limitations of available data. They can then consider any policy decisions that might encourage the production of the best data. For example, absent further cooperation from a generator, using a default emissions rate that might overstate emissions would be simple to administer. It would also encourage a generator to be more forthcoming with accurate data and reporting. As policymakers take a closer look at these challenges and the need for improvements to current practices, they should explore the policy decisions that will provide incentives and promote the production of relevant, useful and standardized energy production and consumption data.

Appendix C: Rate-Making, Pricing and Resource Compensation

Lead author: Mark LeBel

Rate-Making Objectives and Cross-Cutting Issues

When designing rates for 24/7 carbon-free electricity (CFE) transition tariffs, policymakers and stakeholders must pay attention to a wide range of policy goals and rate-making principles. While these rate-making objectives rarely provide specific answers, proper attention to each is necessary to provide a balanced outcome for customers, utilities and market participants that can be integrated into broader utility rate-making structures. This section briefly reviews common policy goals and rate-making principles, before describing the contours of several high-level cross-cutting issues specific to 24/7 transition tariffs, regardless of the specific regulatory context.

Background: Policy Goals and Rate-Making Principles

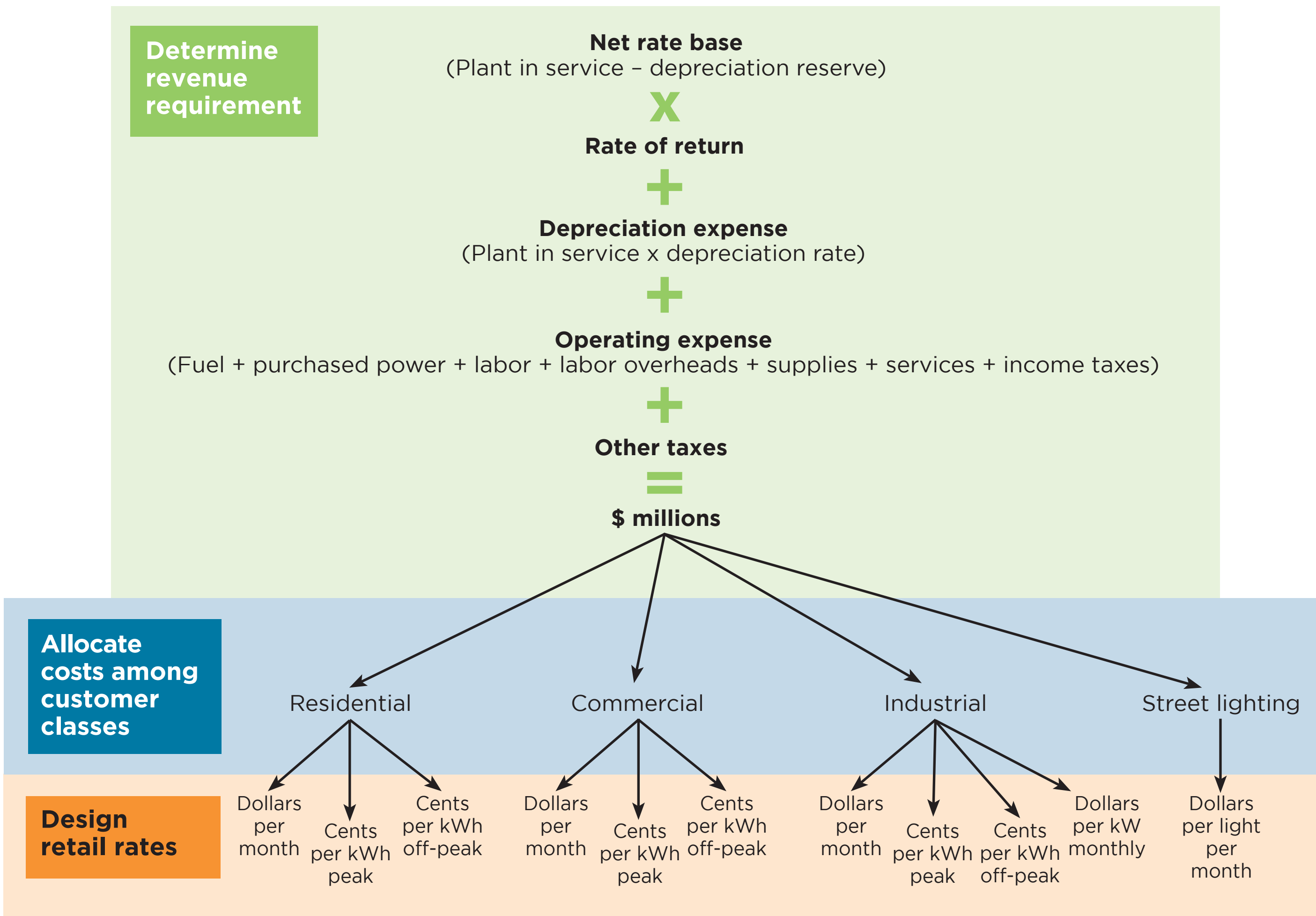
All utility rate-making decisions, including the relevant details for 24/7 transition tariffs, take place within the context of a complex array of policy goals and rate-making principles. Of course, each jurisdiction may have different perspectives and history on the relative importance and interpretation of each goal and principle. Relevant policy goals for each jurisdiction likely include:

- **Provision of safe, reliable and resilient service.** The safety and reliability of electricity service has always been important, but this principle can now encompass the additional concepts of customer and system resilience.
- **Societal equity.** Historically, regulatory goals related to equity have focused on universal access and affordability. Recently, this concern has evolved to include the goal of equitable distribution of benefits and costs of providing energy products and services, including investment patterns and public policy programs.
- **Administrative feasibility.** Modest refinements to existing rules, processes and programs are simpler to adopt. In some cases, larger changes are possible but require additional time, resources and attention from relevant policymakers and stakeholders. In other cases, some theoretically possible reforms may not be feasible or may require other intermediate reforms or investments before they could begin.
- **Innovation and competition.** One of the overarching goals of utility regulation is efficient choices of energy products, services and sources, and, relatedly, allocation of resources across sectors. Although the real world never perfectly matches ideal theoretical conditions, the goal that utilities should be regulated to mimic efficient market outcomes is a worthy one. Customer choice and incentives to invest in new technologies — including technologies that enable customers to change their behavior — can help facilitate efficient long-term outcomes.
- **Public health and environmental protection.** For the past several decades, there have been many state and federal standards and programs

related to electricity generation and delivery that aimed to protect public health and the natural environment. Dating back to the 1970s, they include regulation of criteria pollutants under the federal Clean Air Act.[1] In the past two decades, many states have adopted renewable or clean energy targets that require utilities and other load-serving entities to deliver a certain percentage of clean energy by specific dates. More recently, many states and the federal government have adopted goals and binding requirements for utilities and other emitters to reduce greenhouse gas emissions.

Figure C-1 shows a simplified diagram of the analytical steps of the rate-making process for electric utilities. The prices for each class are typically developed in three high-level steps: (1) determination of the revenue requirement, (2) allocation of costs among customer classes and (3) final design of the retail rates paid by customers.

Figure C-1. Simplified rate-making process



1 U.S. Environmental Protection Agency. (n.d.). *Criteria air pollutants*. https://www.epa.gov/criteria-air-pollutants

In the process of determining the rate structure — a term that combines the cost-allocation and rate-design steps of rate-making — regulators and stakeholders may refer to a range of rate-making principles or guidelines that are more specific than the overarching policy goals listed above. Many lists of these principles have been compiled over the last century by experts and analysts[2] and are still useful today, though they are being revisited based on how changing circumstances may affect them. Some generally accepted rate-making principles that remain relevant include:

- **Effectiveness in yielding total revenue requirements.** The utility should expect that it will have a reasonable opportunity to recover its revenue requirement, or costs to serve, through rates charged to customers, with a degree of stability from year to year.
- **Customer understanding and acceptance.** Prices should not be overly complex such that customers cannot understand how their bills are determined or how they can respond to price signals to manage their overall bills. Different types of customers can reasonably be expected to handle different levels of sophistication. Customers and the public should generally accept that the prices they are charged for electricity service are fair for the service they are receiving.
- **Equitable allocation of costs and the avoidance of undue discrimination.** The apportionment of total costs of service among the different customers should be done fairly and equitably.
- **Efficient price signals that encourage optimal customer behavior.** On a forward-looking basis, electricity prices should encourage customers to use, conserve, store and generate energy in ways that are economically efficient.

It should be noted that there may be trade-offs among these rate-making principles and policy goals in many cases, and the task of policymakers is to strike an overall balance in these objectives.

Cross-Cutting Issues

While many implementation details for 24/7 transition tariffs will vary depending on the regulatory context, there are several key issues that can be considered more broadly.

Electric system value of designated 24/7 CFE resources and allocation of risk

While the cost of a specific set of 24/7 CFE resources may be directly ascertainable, the value to the electric system of those resources may be more difficult to calculate overall. This challenge may vary by the type of benefit. For example, the reduction in fuel and purchased power costs for a vertically integrated utility from designated 24/7 CFE resources can be reasonably estimated on an hour-by-hour basis in every jurisdiction, either in reference to public wholesale market prices in some regions or internal utility data in other places. However, any reductions in short- or long-term future investments in generation, transmission or distribution involve more complex calculations and projections. Best practices for evaluating these impacts include forward-looking system planning that compares scenarios with and without 24/7 CFE infrastructure investments.

2 The most famous of these are the Bonbright principles from Bonbright, J. C. (1961). *Principles of public utility rates.* Columbia University Press. https://www.raponline.org/knowledge-center/principles-of-public-utility-rates/. On Page 291, Dr. Bonbright lists eight frequently cited principles but immediately explains that "lists of this nature are useful in reminding the rate maker of considerations that might otherwise escape his attention, and also useful in suggesting one important reason why problems of practical rate design do not readily yield to 'scientific' principles of optimum pricing. But they are unqualified to serve as a base on which to build these principles because of their ambiguities … their overlapping character, and their failure to offer any rules of priority in the event of conflict." He goes on to discuss his preferred three criteria of "(a) the revenue-requirement or financial-need objective … (b) the fair-cost-apportionment objective … and (c) the optimum-use or consumer-rationing objective" (p. 292).

Among other potential impacts, there is a risk of nonperformance for any set of designated 24/7 CFE resources, much like any other electric system asset. This risk can be financial and could potentially be integrated directly into the 24/7 transition tariff, at least in part. However, there can also be a broader reliability risk for nonperformance of resources at critical times. In addition, the allocation of risk for nonperformance can influence what actions parties take to compensate for that risk. These actions may include certain types of additional contracts with other parties but may also include additional physical investments. For example, to the extent that financial risk is borne by a non-utility generator, that generator has additional incentives to maintain those resources properly, minimize forced and unforced outages, and maximize its output and capacity factor.

End-use customer incentives to manage electric usage

One way a customer can manage the costs of a package of resources to match its load on a 24/7 basis is to shift or reduce its usage.[3] However, efficient customer load management depends on whether the customer has the proper incentive — either directly through the prices in retail rates or indirectly through the price and structure of the tariff or contract with the supplier of 24/7 CFE resources, whether that is a vertically integrated utility, competitive supplier, community choice aggregator or another entity.

In the case of a direct incentive, its presence depends on the retail rate structure. In most jurisdictions around the country, rate structures have been fairly simple to date — primarily a monthly customer charge with flat kWh rates for small customers and a mix of individual customer noncoincident peak[4] demand charges and flat kWh rates for large customers. These traditional rate structures provide little incentive for load shifting, although demand charges do encourage customers to levelize their load. Such rate structures can be reformed to provide better price signals to customers.

In the case of an indirect incentive, a better customer load profile can theoretically allow a customer and any supplier to agree on a lower contract price. Similar logic could be used to structure lower tariff rates from a vertically integrated utility for certain customers. However, such arrangements require provisions to ensure some level of certainty that those customers will continue to maintain those beneficial load shapes. Such provisions can include tariff or contract pricing terms or the customer handing over control of energy usage, in whole or in part, to the supplier or utility.[5]

Cost allocation for grid and information technology investments made by utilities

Grid investments needed beyond those to directly interconnect a new resource to the electric system may include enhancement of system delivery capacity, improved voltage control, increased visibility and communications capability. They are being made not only to facilitate future generation resources generally, but also for system operations to accommodate specific new resources as part of the 24/7 transition tariff. Information technology investments may be necessary to implement

3 Distributed energy resources and their compensation are discussed in a separate section below.

4 Typical retail demand charges in most jurisdictions charge a customer based on their own highest usage in a 15-, 30- or 60-minute interval over the course of a billing period, which can be described as the individual customer's noncoincident peak demand.

5 Interruptible tariffs, where the utility is allowed to stop delivery of power during certain time periods, are an example of customers ceding control historically.

a 24/7 transition tariff but can also serve a broader array of purposes; notably, improved system planning and lower-cost achievement of public policy goals. These investments beyond those to interconnect a 24/7 CFE resource can raise a tension between a narrow "cost causer" cost allocation perspective and a broad "costs follow the benefits" cost allocation perspective. In the narrower view, allocation of these costs predominantly to the incremental resources that require the investments could be warranted. But the broader view is often more appropriate — one where a significant if not overwhelming percentage of these costs is allocated to all customers and resources that benefit from those investments over the long term.

Offerings in Vertically Integrated Jurisdictions

In vertically integrated jurisdictions,[6] where the incumbent electric utility typically maintains a monopoly over the provision of generation services, there are numerous precedents to build upon when we look to establish tariff options to allow customers to achieve their goals for 24/7 CFE.

These precedents can be divided into two categories: (1) where the customer is able to claim credit for purchasing power from specific utility-owned resources and (2) where there is an exception to the monopoly franchise and the customer is allowed to contract for generation services from another entity, such as a non-utility generator. In the first category, analogies can be drawn to existing green tariffs that utilities offer to customers, as well as special contracts. In the second category, there is a long history of exceptions to the monopoly generation franchise that have gone by different labels, such as alternative supply, wheeling and, more recently, municipal aggregation.[7]

Several high-level issues must be addressed across both categories. Table C-1 on the next page lays out the options for addressing them.

While the issues identified in Table C-1 are all foundational, their implications vary depending on whether the potential arrangement is for utility 24/7 CFE resources or for non-utility generation.

6 In several regions, partial restructuring has led to certain kinds of organized wholesale market structures in regions where the electric utilities are still vertically integrated and own generation assets. For our present purposes, we are categorizing such partial restructuring as a vertically integrated regulatory structure, but the precise details will vary in each of those jurisdictions.

7 In some cases, this ended up being a precursor to broader electric industry restructuring, which included changes to the nature of the utility monopoly. This is discussed further below.

Table C-1. Issues and options for 24/7 transition tariff rates in vertically integrated jurisdictions

Issue	Options	Comments
Foundation for rate structure	• Full existing rate • Existing transmission and distribution rate plus new program-specific generation rate • Entirely new rate	Additional charges and credits can be structured around these foundational options.
Eligible load	• New load only • Existing load only • New or existing load	Categories of eligible load may influence what types of incremental charges may reasonably be placed on participating customers.
Incremental costs from 24/7 CFE program	• Administrative costs • Interconnection fee for new resources • Incremental transmission costs • Grid integration costs • Utility incentives • Certain costs for existing generation assets*	Any incremental costs should be properly documented and evaluated for appropriate cost allocation across participating and nonparticipating customers.
Incremental benefits from 24/7 CFE resources	• Fuel and purchased power cost or wholesale market energy cost reduction • Generation resource adequacy contribution or wholesale market capacity cost reduction • Transmission or distribution cost reduction • Resilience benefits • Environmental and public health benefits	Incremental benefits should be properly estimated based on a reasonable value of the resources with appropriate reforms to forward-looking planning.
Length of arrangement	• Term of contract (e.g., 10 years) • Charges for switching back to utility from alternative supply	Additional restrictions may impede 24/7 transition tariff adoption but provide greater certainty for the utility and nonparticipating customers.

** Changes in investment requirements associated with 24/7 CFE portfolio implementation may make some legacy investments uneconomic and may make planned investments unnecessary. Whether this creates a net cost or a net benefit for nonparticipating ratepayers is an important issue that requires quantitative analysis with planning scenarios.*

Offerings of Utility 24/7 CFE Resources

In the case of utilities' 24/7 CFE resources, there are two primary parties to the transaction: the electric utility and the customer. As with other products and services provided by the utility to customers, regulators must find charges or rates for customers seeking 24/7 CFE resources, as well as all other customers, to be "just and reasonable." Key principles for structuring these tariffs include the following.

- Participating customers should cover the net costs of the designated 24/7 CFE resources in order to have a reasonable claim to the energy and carbon-free attributes from those assets and hold nonparticipating customers harmless. Identification of the gross costs of generation from 24/7 CFE assets may be simpler than estimating the system benefits of those resources.
- Structuring the transaction to ensure that the customer (or its supplier/utility) has some incentive to manage and shape consumption may require more sophisticated rate designs than the original generally applicable rate for that customer or else tariff provisions to allow utility control of customer usage in some respects.
- The utility retains primary responsibility for reliability and resource adequacy as the entity responsible for the relevant 24/7 CFE resources, and those costs should be appropriately allocated across participating and nonparticipating customers.
- The utility bears some risk regarding the performance of the designated 24/7 CFE resources because the customer paying for a specific product expects a resolution if that product is not provided. If these resources do not perform as expected, then some arrangement may be necessary between the utility and the participating customer, either in the tariff or negotiated in the future.

Tariffs and Structures for Alternative 24/7 CFE Supply Arrangements

Rate-making structures that allow for generation resources that are not owned, or otherwise controlled and managed, by the vertically integrated utility can be more complex in two particular respects.

First, the non-utility owner and/or operator[8] has independent control over the operation and maintenance of the 24/7 CFE resources. With fair prices and dispatch rules in the relevant agreements with the non-utility resource owner/operator, this should encourage reasonable behavior by the non-utility resource, but some risk may remain for the utility and its other customers.

Second, there are several different options for who is charged and compensated on a routine basis. For example, the customer could be issued a bill by the alternative supplier in addition to a bill from the utility. Beyond the administrative issues with respect to these options, there are financial considerations regarding uncollectibles if the participating customer cannot pay their bills in full.

These complexities come with some benefits and are not unique to 24/7 CFE or our discussion of transition tariffs. Key principles for creating these structures and tariffs include:

- Reasonable incentives, either through the structure of payments for the energy delivered to the grid or through the arrangement with the customers, must be given to the non-utility 24/7

8 The relevant entity controlling the resource may be the customer or an independent entity, depending on the arrangement.

CFE generator to encourage or ensure operation that benefits the electric system proportionate to its compensation.

- Multiple agreements across the relevant entities (e.g., the participating customer, utility and non-utility generator) must be coordinated legally and financially.
- To the extent that the utility relies on the non-utility resource for reliability and resource adequacy, reasonable requirements must be included in the tariffs and agreements to ensure proper resource performance and avoid unnecessary adverse outcomes.

Competitive Offerings in Jurisdictions With Supply Choice

In jurisdictions that have fully restructured at the wholesale and retail levels, regulated utilities generally no longer provide generation services to end-use customers from their own resources. Instead, regulated utilities may procure default generation services through state-defined procedures for those customers that do not choose competitive suppliers.[9] Customers that choose competitive electricity suppliers do so subject to the relevant state rules and wholesale market structures. The price that competitive suppliers offer to end-use customers is typically subject to a significantly lower level of regulation by state utility regulators than traditional rates offered by a utility.

In these jurisdictions, regulators have determined the rate structures under which customers pay the utility for connection, delivery and any other charges (e.g., system benefit charges). It is straightforward to identify what portion of the electricity rate a customer continues to pay to the local distribution utility in addition to the price paid to the competitive supplier for generation services.

In restructured states, larger customers may negotiate with competitive suppliers to meet their overall generation needs in an efficient manner that is consistent with those customers' other policies and goals. Competitive suppliers have frequently procured clean energy for customers under these frameworks and have started to explore how to offer generation services that match the timing of 24/7 CFE supply to load. In this context, the specific product requested by the end-use customer would influence the price that a competitive supplier could reasonably offer. For example, higher 24/7 CFE matching percentages or specific guarantees regarding matching percentages could lead to a higher-priced product, depending on the resource costs.

Distributed Energy Resource Options

Over the past 20 years, the adoption of carbon-free distributed energy resource (DER)[10] options, principally behind-the-meter solar photovoltaic assets, has greatly increased across the United States. In many jurisdictions, this was enabled

9 The exception to this statement in the United States is the restructured portion of Texas that is in the Electric Reliability Council of Texas. In that case, there is no default generation service procured by a utility. Customers are required to choose a competitive supplier, and a "provider of last resort" is an option for customers if their chosen supplier is no longer able to provide service. Public Utility Commission of Texas. (n.d.). *Electricity options: Provider of last resort (POLR).* https://www.puc.texas.gov/consumer/electricity/polr.aspx

10 For our current purposes, we are defining distributed energy resources as limited to generation assets and electric energy storage assets. In some contexts, analysts use a broader meaning for the term, but this is a common definition. For example, Minnesota Public Utilities Commission rules for interconnection define a distributed energy resource as "A source of electric power that is not directly connected to a bulk power system. DER includes both generators and energy storage technologies capable of exporting active power to an EPS." Minnesota Public Utilities Commission. (2019). *Distributed energy resources interconnection process,* p. 33. https://mn.gov/puc/assets/MN%20DIP_tcm14-431769.pdf

by retail-rate net metering structures, where the compensation for behind-the-meter solar generation was tied to the retail kWh rate, although federal tax credits and state-level incentive programs have been quite important as well. More recently, battery storage has started to grow in popularity, with falling costs and supportive public policy efforts at both the state and federal level.

Broadly, solar photovoltaic and storage installed by customers can be thought of as a subset of a broader category of DERs that are either installed behind a retail end-use customer's meter or otherwise interconnected to a utility's distribution system and principally subject to state jurisdiction for the purposes of rate structures and other compensation. Each state also has interconnection procedures and tariffs for these resources to ensure that the electric system can continue to operate safely and reliably with these DERs exporting to the grid. These resources can be part of the package of 24/7 CFE assembled by or for an electricity customer, and all of the regulatory pathways to compensate DERs could potentially be part of the package chosen by a 24/7 CFE customer. Some existing state-level regulatory pathways include on-site net metering structures, virtual or remote net metering policies and virtual power plant structures. Federal compensation mechanisms will likely be relevant as well, either in addition to or instead of state-jurisdictional compensation mechanisms. These include long-term contracts under the Public Utility Regulatory Policies Act of 1978 or the recent direction in FERC Order 2222 to create frameworks for distributed energy resources to participate directly in organized wholesale markets.

Over the past decade, there has been significant debate across the country about the most equitable and efficient compensation structures for DER, which would apply to those DER assets included in 24/7 CFE resource packages for customers.[11] Simpler retail-rate net metering structures were advantageous in the early stages of market development for these technologies. As the relevant markets and companies mature, however, other rate structures may be better suited to the long-run sustainability of these industries, as well as fairer to nonparticipating customers. The wide array of potential reform options includes, but is not limited to:

- Adoption of time-varying rates.
- Reforms to customer charge structures.
- Adoption of "nonbypassable charges," which either cannot be netted away by customers or otherwise are collected through a special billing determinant.
- Changes to the netting period where exported generation directly offsets imported energy.
- Changes to the value of export credits.

The economics of these rate structures for carbon-free distributed energy resources can significantly influence their adoption levels. However, the additional reliability benefits for customers and the local system can also be an attractive feature over and above narrower financial considerations. Related state-level programs for virtual power plants may provide other compensation structures to DERs, and new regulatory pathways may also emerge. As these structures evolve over time, customers that wish to match load and 24/7 CFE supply will likely compare the customer-specific benefits of distributed energy resources to resources from utilities as well as non-utility suppliers.

11 See, for example, LeBel, M., Shipley, J., Linvill, C., & Kadoch, C. (2021, November). *Smart rate design for distributed energy resources.* Regulatory Assistance Project. https://www.raponline.org/knowledge-center/smart-rate-design-distributed-energy-resources-2/; and National Academy of Sciences. (2023). *The role of net metering in the evolving electricity system.* https://nap.nationalacademies.org/catalog/26704/the-role-of-net-metering-in-the-evolving-electricity-system

Recommendations

There are numerous reasonable combinations of choices on the issues discussed in this appendix, but several key recommendations stand out.

RECOMMENDATION 1:

Determine net costs using integrated planning.

- The net costs of designated CFE resources, as well as their system benefits, should be informed by an integrated assessment of the host utility's resource plan and the proposed CFE resource portfolio in those jurisdictions where the utility prepares an integrated resource plan.

RECOMMENDATION 2:

Allocate net costs of CFE to participating customers.

- Participating customers should cover the net costs of the designated CFE resources after all costs and benefits to nonparticipating customers have been accounted for.

RECOMMENDATION 3:

Design incentives to manage the demand side.

- The transaction should be structured to provide reasonable incentives for the management of customer load, and the system benefits provided by well-managed load should be compensated fairly.

RECOMMENDATION 4:

Plan to co-optimize customer and utility investments.

- Opportunities for co-optimizing participating customer investments and utility investments should be evaluated and implemented for the benefit of all consumers.

Appendix D: Operational Requirements

Lead author: Shawn Enterline

There are three categories of infrastructure involved in supporting 24/7 carbon-free electricity (CFE) products: information technology, transmission and distribution, and customer infrastructure.[1] These categories are discussed in the next three sections with an emphasis on how the implementation of a 24/7 carbon-free electricity transition tariff would impact their development, operation and cost.

Information Technology Infrastructure

Time-matched procurement (TMP) is one of the core challenges and a key feature of any 24/7 CFE resource portfolio. TMP implies that the supply of 24/7 CFE matches up with electricity demand at hourly or subhourly intervals, but it need not be perfect. After all, matching 24/7 CFE supplies to demand 100% of the time is not yet an operational reality in regions without large surpluses of hydroelectricity.

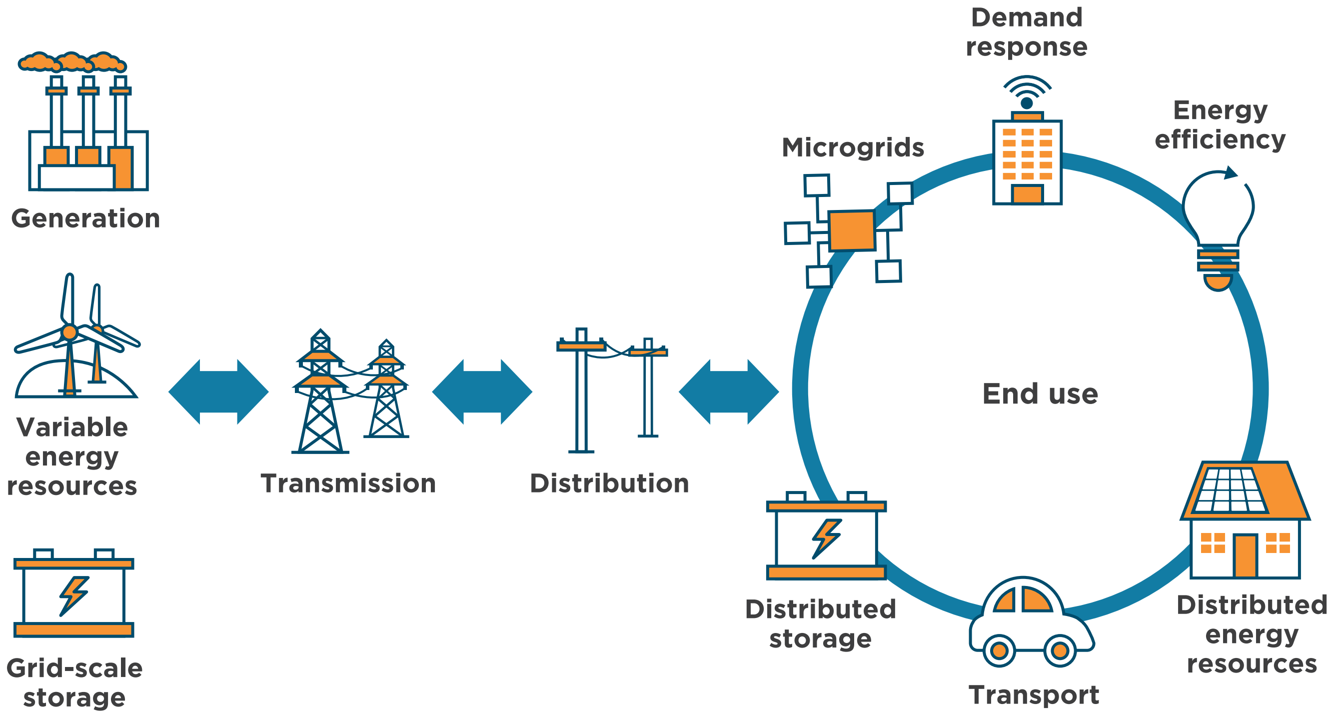
Implementing time-matched procurement will require greater integration and interoperability between various operating systems.

Implementing TMP will require greater levels of system integration and interoperability between the various operating systems that support the grid. The following two figures illustrate the point. The high-level components of the modern, two-way electric grid are illustrated in Figure D-1[2] on the next page. Under the technology neutrality principle of CFE, discussed in Appendix A, all of these resources could contribute to a 24/7 CFE portfolio. For example, combinations of zero and low-emitting supply-side resources could be integrated with combinations of demand-side resources nearer to the customer's location in service of achieving greater levels of TMP.

1 Note that generation infrastructure is not listed. This is because its development is implied by the offering of a 24/7 CFE product.

2 U.S. Department of Energy. (2017, January). *Transforming the nation's electricity system: Summary for policymakers* (Quadrennial Energy Review), p. S-5. https://www.energy.gov/policy/articles/quadrennial-energy-review-second-installment

Figure D-1. Components of the modern two-way electric grid



Source: U.S. Department of Energy. (2017, January). *Transforming the Nation's Electricity System: Summary for Policymakers*

Multiple grid systems must be well integrated to match all of these resources in each hour. Figure D-2[3] on the next page illustrates the full array of these systems and categorizes them using shaded boxes for each of the eight functional areas, labeled "Domains" in the figure:

1. Markets.
2. Operations.
3. Service providers (aggregators).
4. Generation.
5. Transmission.
6. Distribution.
7. Distributed energy resources.
8. Customer.

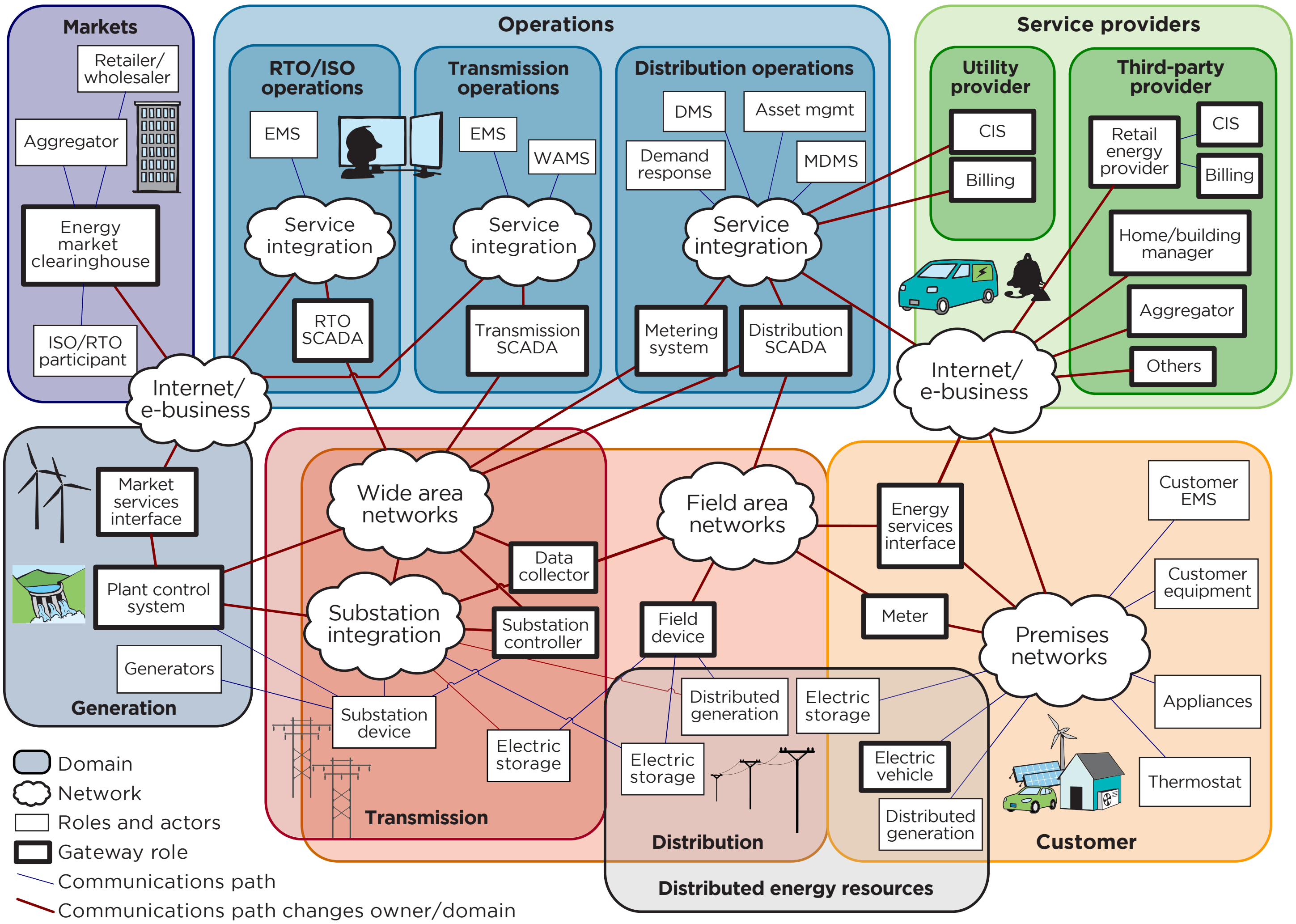
Importantly, the figure illustrates how the systems could be integrated in an ideal world.

In practice, not all of these systems will be integrated or interoperable, and this could create a barrier to implementing a 24/7 transition tariff. This raises the question, "What systems must be interoperable to implement a 24/7 transition tariff?" The answer depends on the design of the tariff, and two boundary cases can help illustrate the point.

First, a completely static, *ex post* 24/7 transition tariff that does not attempt to dispatch supply or demand would essentially be offering customers a 24/7 CFE portfolio design and reporting service. Such a service could use the customer's monthly

3 National Institute of Standards and Technology. (2014). *NIST framework and roadmap for smart grid interoperability standards, release 3.0* (Special Publication 1108r3), p. 139. https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.1108r3.pdf

Figure D-2. Logical model of smart grid information networks



Source: National Institute of Standards and Technology. (2014). *NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 3.0*

bill to report the percentage of 24/7 CFE that was delivered into the balancing authority in each hour. As a result, the systems that would be required to match supply with demand could be limited to three:

1. The customer's metering system, which measures demand.
2. The energy market clearinghouse, which measures supply.
3. The service provider(s) that provide the hourly matching and billing systems.

The other boundary case would be a fully transactive 24/7 transition tariff that dispatches supply and demand on an *ex ante* basis. As depicted in Figure D-2, such a tariff would rely on high levels of system integration among all eight functional areas. Naturally, there is a range of intermediate cases that would require a less comprehensive level of system integration.

In most cases, there will almost certainly be a two-way relationship between the design of the 24/7 transition tariff and the systems that support it. A more dynamic tariff may drive new system integration requirements, and system integration limitations may limit the tariff's scope and design. In all cases, it will be necessary to identify the systems that are impacted by the tariff and the data and functional requirements that are necessary to implement it.

Many of these requirements are being collaboratively developed under the leadership of organizations like the National Institute for Standards and Technology (NIST) and Energy Tag. For example, NIST has published a *Framework and Roadmap for Smart Grid Interoperability Standards* that is in its fourth version as of 2021. NIST's definition of interoperability is insightful. According to NIST,

> "Interoperability — the ability to exchange information in a timely, actionable manner — is a critical yet underdeveloped capability of the power system. Significant grid modernization has occurred in recent years, but the proliferation of technology and associated standards has only modestly improved interoperability.
>
> "The expansion of distributed energy resources and other technologies, along with changing customer expectations, have complicated the interoperability challenge. This revision of the NIST Smart Grid Interoperability Framework uses evolving technology and power system architectures as context for describing a new set of interoperability perspectives.
>
> "Distributed and customer-sited resources figure prominently in the future smart grid, as do intelligent distribution systems and other key integrators. As society modernizes the physical mechanisms by which we produce, manage, and consume electricity, strategies for system operations and economic structure will diversify. This diversification will benefit from — and eventually rely upon — enhanced interoperability."[4]

Similarly, EnergyTag has published an initial standard for issuing "granular certificates," which represent the environmental attributes of electricity generation as separate from physical power delivery.[5] Granular certificates are hourly versions of energy attribute certificates, and they enable the owner of the certificate to claim the use of that unit of energy generation. As such, they represent a crucial step in the development of hourly matching standards that support 24/7 transition tariffs. Taken together, the NIST and EnergyTag standards are essential resources and will be important to consult as 24/7 CFE portfolios are being designed and implemented.

Transmission and Distribution Infrastructure

When large new resources or loads are connected to the electric system, a series of engineering studies are conducted to assess what infrastructure upgrades are required to integrate the resource or load into the grid. If the ratings on any number of grid components are exceeded or a reliability scenario is identified that requires additional infrastructure or protection equipment, then a facilities study is conducted to estimate the cost of the necessary upgrades.

4 Gopstein, A., Nguyen, C., O'Fallon, C., Hastings, N., & Wollman, D. (2021, February). *NIST framework and roadmap for smart grid interoperability standards, release 4.0* (Special Publication 1108rev4), p. i. https://www.nist.gov/publications/nist-framework-and-roadmap-smart-grid-interoperability-standards-release-40

5 EnergyTag. (2021). *EnergyTag and granular energy certificates: Accelerating the transition to 24/7 clean power,* p. 6. https://www.energytag.org/wp-content/uploads/2021/05/EnergyTag-and-granular-energy-certificates.pdf

When large new supplies are added to the grid, these costs are typically paid by the developer under the “cost causer pays” principle. When the cost of upgrading the system is prohibitively high for the developer to bear, then the project may be shelved. As new 24/7 CFE resources are connected to the grid over time, the hosting capacity of the grid can be expected to decrease, and the cost of interconnection can be expected to increase. At some point, further 24/7 CFE development can be expected to slow down and become more challenging because of the increasing cost of interconnecting to the grid.

The alternative is to socialize some or all of the interconnection costs for a specific project or to increase the hosting capacity of the grid generally. In both cases, nonparticipating customers would pay more, which may raise equity concerns.

These concerns are traditionally addressed during system planning and rate design/rate-making proceedings. In both cases, stakeholders are brought together to identify concerns, consider alternatives and negotiate compromises. In the context of developing a grid that includes ever higher percentages of 24/7 CFE resources, the importance of these proceedings also rises. The implication for developing 24/7 CFE products is that using best practices for stakeholder engagement, system planning and rate design/rate-making will become ever more important.

Customer-Side Resources and Infrastructure

A customer who subscribes to a 24/7 CFE product has an incentive to make investments to align its own demand with the available supply. The capability to increase demand when carbon-free energy is abundant, or to decrease demand when CFE resources are scarce, can reduce the cost of the 24/7 CFE product compared to a customer whose demand is inflexible.

The majority of customer investments are likely to be behind the retail meter. If the flexibility of those investments is unmetered, then the benefits the customer can expect will be realized solely through the net load at the retail meter and compensated through the design of the 24/7 CFE rate.

In addition to reducing its own costs, a customer’s efforts to shape and control its own demand can also reduce the cost of operating the grid. For example, decreasing demand when 24/7 CFE resources are scare can not only reduce the customer’s retail bill, but also create grid services such as demand response, operating reserves and even frequency and voltage regulation.

To realize some of the value of the grid services it provides, the customer must invest in submetering. This not only makes the grid services measurable, but also enables them to be aggregated for use by grid operators. Then, under FERC Order 2222, the customer may be eligible for compensation for the grid services they provide.

The implication for the 24/7 transition tariff is that 24/7 CFE customers will have to make a choice whether to meter their investments in on-site flexibility. A customer that chooses to meter may then use FERC Order 2222 to seek compensation from the grid operator. In theory, the load-serving entity offering the 24/7 transition tariff could use the tariff itself to flow through some or all of this value to the customer. If the customer chooses not to meter their load flexibility, the value of that flexibility would accrue to the customer by offsetting charges on their electric bill.

Recommendations

Time-matched procurement is one of the core challenges and a key feature of any 24/7 CFE resource portfolio. Implementing TMP will require greater levels of system integration and interoperability. The data and functional requirements that will enable hourly matching are being collaboratively developed under the leadership of organizations like the National Institute for Standards and Technology and EnergyTag. These collaborations and the standards that they publish are essential resources and will be important to consult as 24/7 CFE portfolios are being designed and implemented.

With these standards as a guide, we recommend that load-serving entities move from an *ex post* to an *ex ante* implementation of their 24/7 transition tariff using the following high-level sequence of interoperability improvements.

RECOMMENDATION 1:

Consult the latest standards when developing 24/7 CFE products.

- Load-serving entities and other providers of 24/7 CFE products should consult the latest NIST, LF Energy Standards and Specifications (https://lfess.energy) and EnergyTag standards during the design and implementation phase of their 24/7 CFE products/portfolios.

RECOMMENDATION 2:

Implement 24/7 CFE products based on *ex post* systems first.

- This involves integrating the customer, markets and service provider domains. These domains form the foundation of future system integration efforts.
- Specifically, the service provider's systems must be sufficiently integrated with the customer metering system and the markets domain to enable three outcomes. First, supply and emissions data must be matched with demand. Second, the emissions and the CFE percentage of the portfolio must be calculated by hour. Third, the customer must be billed using the 24/7 transition tariff, including a report on the portfolio's emissions and 24/7 CFE percentage.

RECOMMENDATION 3:

Implement fully transactive, *ex ante* 24/7 CFE products second.

- This involves integrating the distribution, distributed energy resources (DERs), distribution operations and service provider domains.
- Service providers offer distributed energy resource management systems (DERMS) that help make these domains interoperable. From an operational perspective, the DERMS manage the resources within the DERs domain and coordinate them with the distribution operations domain. From a planning perspective, the DERMS represent a database of aggregated resources that can be included in distribution planning within the distribution domain.
- By integrating these systems, load-serving entities can capture the operational benefits at the distribution level and prepare the DERMS to integrate with the balancing authority under FERC Order 2222.

Regulatory Assistance Project (RAP)®
Belgium • China • Germany • India • United States

50 State Street, Suite 3
Montpelier, Vermont 05602
USA

+1 802 223 8199
info@raponline.org
raponline.org

Energizing
CHANGE