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Introduction

Energy efficiency has long been touted as a cost-effective way to meet climate change mitigation goals. A 2014 American Council on Energy Efficiency (ACEEE) report found that energy efficiency, with an average cost of 2.8¢/kWh saved is far below the cost of other forms of generation like wind, coal, natural gas, biomass, and nuclear energy, which range from 3-15¢/kWh (ACEEE, 2014). Twenty-nine states now have energy efficiency resource standards, which require electric power producers to reduce their constituents' electric loads. Targets for these reductions are set in the future and typically increase over time. For example, Minnesota's Energy Efficiency Resource Standard requires reductions of 1.5% average electric sales annually (DSIRE, 2018).[1] In order to meet these types of energy efficiency reduction targets, provisions that would allow energy-savings certificates, which usually represent Megawatt-hours (MWhs) of energy savings, to be traded amongst regulated entities are in place in Connecticut, Nevada, and Pennsylvania. This energy-reduction credit trading also exists in Italy, the Australian states of New South Wales and Victoria, Great Britain, Denmark, and France (Hamrin, Vine & Sharick, 2007).

The name of these energy reduction certificates differs based on the market where they exist. For example, Connecticut calls them Conservation Credits or Class III RECs, and, in these markets they each represent one Megawatt-hour (MWh) of energy savings. Within voluntary U.S. markets, they are termed White Tags®, as coined by the private company Sterling Planet who originates them and each represents one MWh or 1000 cubic feet of natural gas saved. Within the Italian market, they are called Energy-Saving Certificates (ESCs) and are equal to one metric ton of oil equivalent. This paper will refer to these tradable instruments as a "white certificates" when used in a general way and when they are not linked to a particular compliance program since this is most internationally-recognized name for them.

The idea to use tradable white certificates has its origins in both the cap-and-trade markets for sulfur oxide, nitrogen oxides, and greenhouse gases and in the renewable energy certificate markets. In these markets, entities can either make changes to their equipment to reduce their own emissions, or they can choose to purchase credits from other suppliers that can be used towards their own targets. Within sulfur oxide, nitrogen oxides, and greenhouse gas markets, reductions made elsewhere can be purchased and claimed by the entity that claimed them in lieu of reductions made onsite. Within renewable energy markets, Renewable Energy Certificates (RECs) representing one MWh of electricity can be sold to entities that must comply with required state-level targets for renewable energy generation or to voluntary customers who want to support renewable energy.

In the early 2000s, many market observers thought that white certificates would have the same success as RECs. However, no organization followed through with the creation of a standard for

[1] A table of Energy Efficiency Resource Standards existing to date in U.S. states can be found in Appendix A.

white certificates because of difficulties with the public perception of this intangible commodity and challenges. Despite the difficulty white certificates had in the voluntary market and within the U.S. in general, they have helped other countries meet their energy-reduction goals economically, and in many countries have well-developed accounting, monitoring, and verification systems. The mechanics of how white certificates can be used to create emission reductions works slightly differently in each market, but in general the steps include:

1. A baseline of electricity and/or heat usage[2] is established for facility or groups of buildings that will serve as the project boundary. It is essential that this baseline be accurate, and ideally should consist of an average of several years of data to account for weather abnormalities. This baseline will serve as a counterfactual point that can be used as a comparison to the electricity and/or heat usage after the project has been completed.
2. A regulated entity either creates energy reductions by installing more efficient equipment or changing consumer behaviors, or the entity may purchase certificates from a market, an Energy Service Company (ESCO), or another company who has made these reductions themselves or on behalf of a client. The client uses accepted technologies to achieve these reductions and uses approved monitoring and verification to ensure that these energy reductions are made.
3. The regulated entity may use these white certificates to reduce their overall emissions or energy usage.
4. The regulated entity surrenders enough white certificates to equal their required emission or energy reductions to the regulatory agency. (Sometimes a third party must verify the energy savings before they are submitted to the regulatory body.)
5. A regulatory agency audits the emissions or energy reductions claimed and verifies them by either comparing energy and/or heat usage to the baseline established or to models that reflect an average usage for a particular facility without energy efficiency upgrades.
6. The white certificates are tracked and retired by the regulatory agency to comply with state or federal legislation.

By trading white certificates, regulated entities are theoretically able to lower their overall cost of compliance as the cheapest reductions possible within the market territory are able to be made and are fungible throughout the market. Preliminary research in this area has in fact shown that these certificates are cost effective (Giraudet & Finon, 2015) and some countries like Italy have adopted this program and implemented it on a wide scale in order to provide cost containment (Pela, 2015).

Given this reality, this paper investigates the current status of tradable white certificates, the challenges that exist to these programs, and their future potential. Section 1 investigates the current market status of white certificate markets in the U.S. and those abroad. Then, Section 2 will address specific challenges to trading white certificates, why these challenges exist, and

[2] Some white certificate programs award certificates only for electricity savings, whereas others award certificates for natural gas saved. Therefore, the authors have referred to both heat and electricity usage here.

how white certificate markets have approached these obstacles. The challenges that will be addressed include the definition of a white certificate, its ownership, and the tracking of white certificate sales. After the introduction to each of these challenges, this paper will discuss how these issues are being addressed in each market. Section 3 will discuss the future potential for trading of white certificates in the U.S. through future national legislation as proposed in the Clean Power Plan, under state Energy Efficiency Resource Standards, and in voluntary markets.

Section I: Current Market Status of White Certificates Worldwide

Trading in U.S. States

Twenty-nine states have requirements for energy efficiency that oblige utilities to reduce their customers' demands by certain percentages before target dates in the future, though only three states have formally undertaken trading schemes to manage this commitment. The following section examines Connecticut, Michigan, Nevada, and Pennsylvania where trading has occurred. Sometimes these requirements exist in stand-alone legislation, but often they are a part of the state's Renewable Portfolio Standard (RPS), which requires that a particular state's electrical providers source a certain percentage of their energy from renewable sources. There are usually target dates specified for these requirements, and the amount of renewable energy required usually increases over time. As a part of these RPSs, there is sometimes a carve out requiring a certain percentage of this renewable energy to be sourced from solar energy, or from energy efficiency measures. And, if the state legislation allows, energy reductions can be met by onsite reductions and/or through trading of white certificates. The details of the programs in states with white certificate activity will be discussed in alphabetical order below. Information related to the challenges that white certificates face will be discussed in Section 2.

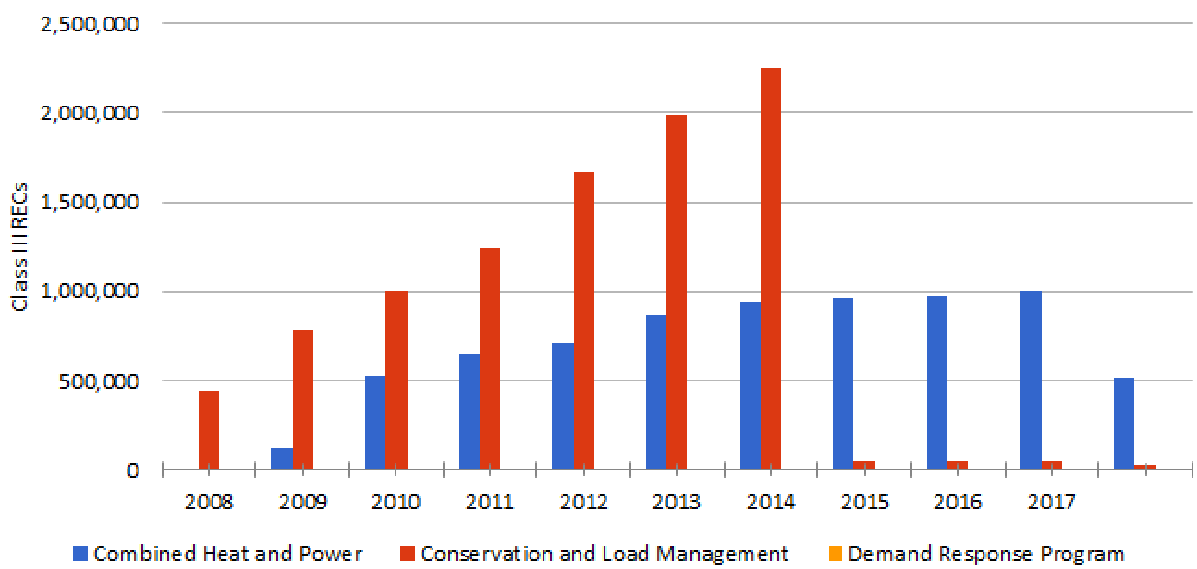
Connecticut

Connecticut has an RPS requirement that 28% of the state's electricity be classified as either a Class I, II, or III REC by 2020. Class I and II are varying types of renewable energy, and Class III includes energy efficiency and conservation, combined heat and power projects, and systems that recover waste heat or pressure from commercial and industrial processes. The RPS specifies that four percent of that 28% must be a Class III REC (DSIRE, 2017b). Investor-owned and competitive electricity providers must own and retire enough Class III REC certificates annually or pay an alternative compliance payment of $31/MWh (Holt, 2010).

Even though trading of these Class III RECs has been allowed since 2007, little has occurred because there is a surplus of certificates. The Class III REC price floor is $10/MWh, and the price ceiling is $31/MWh (Connecticut Department of Energy and Environmental Protection, 2013). In 2008, the average price of a Class III credit was about $21-$26/MWh, but in 2010, the Class III RECs traded near the price floor of $10/MWh and have remained there (Nelson, 2012; Holt, 2010). If this price floor were not in place, then these Class III RECs would trade at even lower prices of possibly $2-3/MWh due to the oversupply (Maddox, personal communication, December 14, 2017).

The New England Power Pool Generation Information System keeps track of RECs traded by type and quarter. Figure 1 below shows interesting trends in these REC projects thus far. Conservation and Load Management (C&LM) projects were favored at the beginning of the market, but then waned in popularity in 2014 due to the low prices and the cost and complexity involved in monitoring and verifying these projects. Combined heat and power projects have steadily gained in popularity because of the simplicity of metering these projects, instead of having to use statistical sampling and deemed savings for individual, civil-sector energy efficiency measures, which is necessary for C&LM projects. Demand response programs have not been successful at all, perhaps due to their costliness to implement.

Figure 1: Connecticut's Class III RECs by Type from 2007-2016 (NEPOOL GIS, 2017)[3]



The surplus of these combined heat and power Class III RECs and attendant trading at the price floor since 2010 can be attributed to the many ways in which energy savings projects are completed in Connecticut. Firstly, retail customers are assessed $0.003/kWh as a system benefit charge, which goes into a Conservation and Load Management Fund (C&LM). The statewide energy efficiency budget from these programs for 2018 is $268 million (Eversource Energy and others, 2017). These funds can be used to create Class III RECs by utilities, which helps these utilities generate a surplus of these Class III RECs. Revenues from the Class III REC sales are reinvested in the C&LM programs.[4] Secondly, energy efficiency and demand response can bid into the forward capacity market in ISO New England; negating the need for a MWh is valued just as much as generating a MWh in this market. The forward reserve threshold price was $990/MW for Oct-May of 2015-2016 (ISO New England, 2017). Thirdly, the Regional Greenhouse Gas Initiative (RGGI) invests 70% of the proceeds from allowances that are auctioned off into energy efficiency programs (Connecticut Department of Energy and Environmental Protection, 2014). The value of these allowances in 2017 was over $4 million; 70% of those allowance proceeds go into energy efficiency, which means that in 2017, over $2.8 million from RGGI allowances went into energy efficiency projects (Connecticut

[3] The demand response program did not generate enough Class III RECs to be seen on the scale of this chart.
[4] Until 2010, utilities could sell these credits through long-term contracts, requests for bids, and brokers; however, regulation in 2010 required utilities to sell Class III credits from their C&LM programs in a combined request for bids conducted quarterly. Under this 2010 regulation, utilities now are unable to meet their own needs for credits from their own programs, and instead must procure them from wholesale energy suppliers (Holt, 2010).

Department of Energy and Environmental Protection, 2014). The systems benefit charge, forward capacity auctions, and RGGI proceeds all benefit energy efficiency projects in Connecticut. However, all of these programs also help to flood the market. The overlap of programs creates redundancy and prevents the tradable certificates from working as they do in other countries where the least costly projects are pursued. Instead, in Connecticut, these certificates trade at the price floor and there is a lack of project diversity because of an oversupplied market.

Michigan

Michigan also allows for energy efficiency and conservation to count towards its state RPS (under PA295, the Michigan Energy Optimization Act), which requires 15% of utilities' electricity to be sourced from renewables by 2021 (DSIRE, 2017a). The name of the credits created from the energy efficiency and conservation activities under the RPS are called Energy Optimization Credits (EOCs) and not allowed to be traded outside of a service territory among utilities, but could be gathered from industrial customers and traded within a territory (Hathaway, personal correspondence, December 18, 2017). Sterling Planet capitalized on that provision and developed several projects described in Box 1. In general, Sterling Planet utilizes a client's baseline energy use and creates a forecast of energy use, then is able to compute savings generated from energy efficiency. Each MWh of savings from the baseline is counted as a White Tag, and can be measured, validated, and delivered to Sterling Planet clients.

Nevada

In Nevada, 20% of the RPS (which requires the utilities to source 25% of their electricity from renewable sources by 2025) can be fulfilled with demand-side management[5] and energy efficiency (DSIRE, 2016). Although trading is allowed in the legislation, there are very few power providers that must comply, and therefore, the trading pool is limited. NV Energy comprises Nevada Power Company and Sierra Pacific Power Company, which are owned by Berkshire Hathaway Energy Company, and serves 90% of the state (Berkshire Hathaway Energy, 2017). The other utility that must meet RPS compliance is Shell Energy, which provides energy for Barrick Goldstrick, Turquoise Ridge, and Cortez Mines. Originally NV Energy and Shell Energy could fulfill 25% of their RPS requirements with energy efficiency measures, but in 2013, changes were made to sunset that amount to zero by 2025 (DSIRE, 2016). The use of energy efficiency was added to the RPS to reduce the cost of complying with the regulation and is seen by renewable proponents as weakening the RPS (Sullivan, personal communication, December 1, 2017). For these reasons, it was put on a schedule to be phased out (DSIRE, 2016). Energy efficiency is now primarily being driven by the integrated resource plan, which requires NV Energy to consider all possible forms of meeting future demand and to rank them by their cost effectiveness (Sullivan, personal communication, December 1, 2017).

[5] Demand-side management will be mentioned throughout this paper. It refers to changes in customers' energy use and patterns due to behavioral or technological modifications (EIA, n.d.).

Box 1: Sterling Planet White Tag Sales in Michigan

Sterling Planet is a corporation that provides carbon offsets, renewable energy certificates, white certificates (dubbed White Tags®), and analytics. They introduced White Tags to the market in 2006 and have had a few successful trades of them. Sterling Planet defines a White Tag as one MWh of electricity savings or 1,000 cubic feet of natural gas savings and touts them as "[creating] a significant economic and administrative benefit. They are a readily procured, economically priced commodity that eases the burden of compliance with state energy-efficiency mandates and also accommodates utility budgets" (Sterling Planet, 2011). There is no definitive list of approved technologies that qualify for the generation of White Tags, and a time horizon associated with these White Tags is not defined. Sterling Planet analyzes the baseline energy use of a client over a 36-month period. Using proprietary software to correct for weather, Sterling compares forecast and actual usage. If the actual usage is lower than the forecast, then White Tags are generated (Sterling Planet, n.d.). Sterling Planet measures, validates, and delivers white tags to their clients.

In 2011, Sterling Planet derived EOCs from customers in Detroit Edison's and MichCon's Commercial and Industrial territories. The EOCs were derived from both electricity and natural gas savings and were delivered to DTE Energy for compliance use. While the total number of EOCs generated was not made public, Sterling Planet did reveal that the energy savings verified by the program will compare to a 11.7-metric ton reduction in carbon dioxide emissions (Sterling Planet, 2011).

In 2012, Sterling Planet completed the first White Tag transaction between Michigan's Selfridge Air National Guard Base and a Michigan utility for use in the state RPS. Selfridge installed more efficient lighting, HVAC systems, and pursued behavioral changes such as turning out lights to earn these White Tags. The White Tags were sold to DTE Energy to help meet its obligations under the state RPS (Sterling Planet, 2012).

Building on this momentum, Sterling Planet created White Tags from General Motors Corporation in 2013. The White Tags were created over a two-year period as GM implemented an automated "switch and stage" maneuver for dynamic air compressor operation at the GM Romulus Engine plant in Romulus, MI. This improvement over manual methods of switching on this air compressor generated 1,000 White Tags (Sterling Planet, 2013).

If energy efficiency was not being phased out of the RPS, there could be an opportunity for more trading as Nevada passed an Energy Choice Initiative that was on the ballot in November 2016. This initiative, which would allow for independent power producers to compete in this market, needs to pass another round of voting in 2018 before it becomes a constitutional amendment (Ola, 2016). Having more independent power producers would broaden the field for trading Energy Portfolio Credits, the Nevada term for white certificates.

Currently, NV Energy does not purchase credits to comply with the RPS from anyone since their internal program is generating and documenting more savings than necessary. In 2016, NV Energy fulfilled their RPS requirement with 17% of demand-side management projects, which was close to the cap of 20% allowed (NV Energy, 2017). NV Energy has several energy efficiency programs for customers, for which they retain credit when reductions are made through these programs. The Sure Bet Direct Incentive Program is meant for businesses and the Energy Smart Schools targets schools of all levels (DOE, n.d.; DOE, n.d.). Since the amount of the portfolio that can be derived from energy efficiency is declining, the prospects for future trading of white certificates in the state is not promising.

Trading Energy Portfolio Credits from energy-savings or renewable energy generation across state lines is almost non-existent due to the differences between these credits and other RECs. Not only does energy efficiency qualify as a Portfolio Credit, and the unit of the credit is a kWh instead of the MWh that RECs represent, but there are credit multipliers that further complicate the fungibility of this tradable instrument. Residential photovoltaic systems installed before 2015 receive a 2.4 credit multiplier while electricity saved during peak hours is credited with a 2.0 multiplier (DSIRE, 2016).

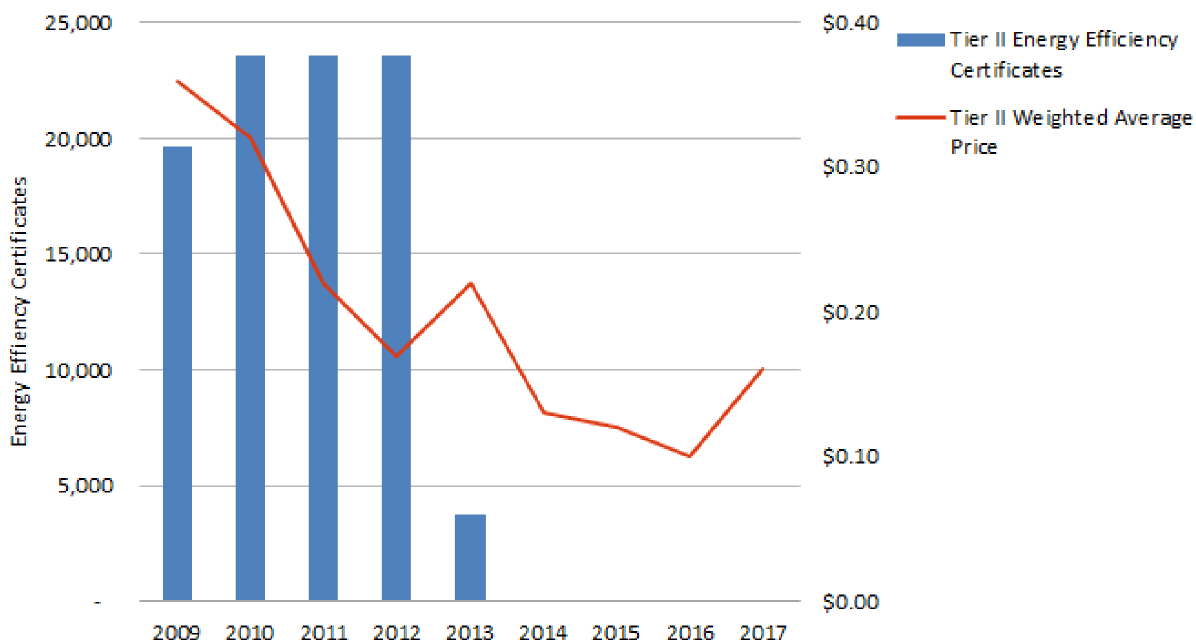
Pennsylvania

While the state of Pennsylvania allows for trading of white certificates in their state energy policy, very little of this trading has occurred there. In Pennsylvania, there are two pieces of legislation related to energy efficiency: one is Act 129 Phase III Energy Efficiency and Conservation Plans and the other is the Renewable Portfolio Standard, which allows energy efficiency to qualify as a Tier II resource and allows for trading. Act 129 was passed, even though the RPS was in place in 2008 because of escalating costs of electricity. Due to the increased availability of natural gas, these escalating rates did not continue. However, there was no sunset clause put on Act 129, and it currently serves as the most direct way of supporting energy efficiency projects (Gebhardt, personal communication, December 8, 2017).

The RPS, known as the Alternative Portfolio Energy Standard, requires 18% of electricity to come from qualifying resources by 2021. Pennsylvania required Tier II credits to make up 4.2% of the RPS in 2007 and scaled this requirement up to 10% by 2010 (Pennsylvania PUC, n.d.). These Tier II RECs, which include waste coal, distributed generation, demand-side management, large-scale hydro, municipal solid waste, wood pulping, and combined heat and power plants, are trading at $0.10-.25/MWh each and are over-subscribed. The Tier II RECs have a lifetime of 2 years after creation and are also good the year in which they are created, essentially making them eligible for up to three years. In order to create RECs from eligible projects, the project must go beyond the required building standard. In Pennsylvania, standards are outdated and many buildings are not even meeting this outdated code. Therefore, to bring buildings up to code and go beyond this code, huge investments would be needed (Sherrick, personal communication, November 29, 2017). Also, if Tier II RECs are created with the help of any rebates, then the proceeds from these RECs have to be reinvested in the program, creating a logistical burden for electric distribution companies as they attempt to differentiate these subsidized RECs and track them.

The Pennsylvania Jersey Maryland Generation Attribute Tracking System (PJM GATS) is used to track RECs in the state. At the start of the program in 2009, Tier II prices were $0.36/MWh and stimulated some energy efficiency projects in this area, but they still only made up 0.05% of the projects in the Tier II category. The prices of Tier II RECs were low in 2017 at $0.16/MWh because this REC category is over-supplied with waste coal and pumped hydro storage. These low prices have led to low volumes of energy efficiency projects developed, as shown by Figure 2. Energy efficiency Tier II RECs made up just 0.09% of the RECs in this category in 2012 (PJM Interconnection & Environmental Information Services, n.d.).

Figure 2: Pennsylvania's Tier II Energy Efficiency Certificate Volumes and Prices (PJM Interconnection & Environmental Information Services, n.d.)



Possible Implications of a U.S. National Energy Efficiency Resource Standard

At the U.S. national level, an energy efficiency resource standard has been introduced to Congress in the past by Representative Ed Markey's "Save American Energy Act" of 2009 and may again be considered under future administrations given the cost-effectiveness of energy efficiency compared to other greenhouse gas mitigation methods. Creating a national market now after 29 states have already begun state-designed programs could lead to money flowing into states that do not currently have targets as the cheapest, low-hanging fruit would be captured first. From an economic standpoint, this may seem like the best possible option as reductions could be made cheaply. However, states that were early adopters of energy efficiency standards would see money from their ratepayers flow out of their states as their utilities procure white certificates from other states. Also, the prospect of national legislation which could take another decade to pass, could cause late adopter states to be resistant to adopting state-level legislation since they would stand to gain financially if they waited until the market was implemented at the federal level. The market would encourage developers to aggressively pursue projects in states with no existing standards and a plethora of low-hanging fruit. There is also the possibility that emission hot spots could form as electricity suppliers that purchased white certificates from elsewhere would burn more fuel to serve their populations with increasing energy demands (Loper and others, 2008).

Programs Abroad

Italy, France, the United Kingdom, Denmark, Poland, and Australia have developed white certificate programs with varying degrees of success. The details, volumes, and trades of these programs will each be discussed (in alphabetical order by country). Because the units of white certificates in each of these countries are different, the authors have made an effort to allow the reader to compare white certificate programs by providing a conversion to express white certificate prices in terms of USD/MWh, which is the unit used by all U.S. white certificate programs, except Nevada. Also, a full comparison of programs in terms of volumes of white certificates generated and price can be found at the end of this section in Figure 7. In section two, details of these programs that relate to the additionality, monitoring and verification, lifetime of certificates, interaction of white certificate programs with existing greenhouse gas legislation, and other details will be discussed.

Australia: New South Wales

New South Wales, Australia developed the first operational white certificate trading scheme worldwide in 2003 (Hamrin, Vine & Sharick, 2007). The scheme is known as the Energy Saving Scheme (ESS) and was established initially under Part 9 of the Electricity Supply Act 1995. ESS targets ramp up to reductions of 8.5% of electricity sales by 2019 and then remain steady there until 2025. Electricity suppliers are responsible for holding and submitting for retirement the appropriate number of certificates, each of which represent one MWh of electricity saved or an equivalent amount of natural gas, annually to meet the targets.[6] As of 2016, certificates can be created for gas-saving activities, as well as electricity-saving activities. Independent Pricing and Regulatory Tribunal (IPART) regulates the Scheme for the participants and administers the Scheme for the Accredited Certificate Providers, who can create certificates (IPART, 2016).

While electricity suppliers can apply to be Accredited Certificate Providers (ACPs), most energy savings are created through third parties who sell white certificates to the electricity suppliers (Nadel and others, 2017). There are 91 active ACPs, and about 20% of them are regulated entities, such as heavy industries, commercial property groups, and supermarket chains that carry out activities at their own site. ESCOs dominate the market, and some of these ESCOs

[6] Exempt from consideration of this target are electricity sales to emissions-intensive and trade-exposed industries.

serve the role of completing necessary paperwork, but do not actually perform the energy upgrades themselves; instead they subcontract that work to electricians and other industry professionals (IPART, 2016).

In 2016, over 3.79 million certificates were retired, and since the inception of the ESS, over 15.3 million have been surrendered and over 21.6 million have been created in total. The government has not created a trading platform and instead has let the market take over that role and cost. Bilateral trades are common, and several companies have created spot markets. In 2016 and 2017, prices fluctuated between $11 AUD/MWh ($8.70 USD/MWh) and $28 AUD/MWh ($22.14 USD/MWh). In November of 2017, prices were $22 AUD/MWh ($17.47 USD/MWh) (Green Energy Markets, 2017). There is no price floor in this market, as others have, but the penalty price of $27.48 AUD/MWh in 2017 serves as a price ceiling. This penalty changes annually (IPART, 2016). In this scheme, the market sets the price floor based on the lowest cost of energy savings available, which allows for higher net economic benefits. However, the scheme lacks diversity in energy savings and tends to be dominated by lighting upgrades, which account for 70-80% of the certificates (Michael Oppermann, personal communication, December 7, 2017). Also, there is the possibility of a market bust, as occurred in the first E.U. Emission Trading Scheme of 2005-2007 when the E.U. Allowance dropped to €.10 by May 2007 (Chevallier, 2010).

Australia: Victoria

In Victoria, Victorian Energy Efficiency Certificates (VEECs) are traded. Like the U.K. scheme, each VEEC represents one metric ton of carbon dioxide (CO_2) abated, and those entities responsible for making reductions are the large energy retailers, who can make reductions themselves and/or buy them from a third party. The scheme has had three phases. The first phase from 2009-2011 had a reduction target of 2.7 million VEECs annually; the second from 2012-2017 had a reduction target of 5.9 million VEECs annually; and the third phase from 2018-2020 beginning with a target of 6.1 million VEECs per year, which then increases to 6.5 million per year. The 2020 target equates to 2% of Victoria's electricity sales (Essential Services Commission, n.d., Sustainable IT, 2015 and Dept. of Industry, Innovation, and Science, 2016).[7] Similar to the New South Wales' scheme, all energy reductions to meet these targets must be made through VEEC creation or purchase (Essential Services Commission, n.d.).

Several pieces of legislation, including the Victorian Energy Efficiency Target Act 2007, the Victorian Energy Efficiency Target Regulations 2008, and the Victorian Energy Efficiency Target Regulations 2017, are responsible for these targets. There are 37 activities that can earn certificates, and these activities range from installation of high efficiency hot water systems, air heaters/coolers, lighting retrofits, draft-proofing and window treatments to the purchase of high efficiency appliances. For $500, an entity can apply with the Australian Essential Services Commission to become an "Accredited Person" who is eligible to develop projects. If a project

[7] 1410 PJ of total energy consumption in Victoria = 3.9 x 10^8 MWh
3.9 x 10^8 MWh * 0.8136 t CO_2/1 MWh (average grid emission factor for Australia) = 3.12 x 10^8 t CO_2
6.5 x 10^6 total VEECs/3.12 x 10^8 t CO_2 (total emissions from energy consumption in Victoria) = 0.02

submitted by an Accredited Person is accepted after review, a registration fee of $1 per VEEC is levied. In some cases, VEECs are not issued until an old appliance has been rendered permanently unusable (Essential Services Commission, n.d.).

The government does not host a market for trading certificates; instead trading is done bilaterally or through spot and futures markets that have been developed by private companies. Since 2016, the prices of VEECs have fluctuated between $10-$20 AUD (Demand Manager, 2017). The price of a VEEC was $19.60 AUD ($12.39 USD /MWh)[8] as of December 2017. Over 10.7 million VEECs have been registered or are pending registration and over 35.2 million have been surrendered for compliance purposes (Essential Services Commission, n.d. and Sustainable IT, 2015).

China

In November of 2010, the Chinese government issued "Guidance on Electricity Demand-Side Management Regulations," which requires the grid companies to produce energy savings equivalent to at least 0.3% of electricity sales in the previous year and to reduce demand by at least 0.3% of maximum load in the previous year. The rule applied to the State Grid Corporation and China Southern Grid, the two, large government-owned entities that operate electricity transmission and distribution networks and supply electricity. Within this rule, trading of white certificates was accepted for up to 40% of target reductions.

The State Grid Corporation and China Southern Grid could purchase certificates from customers or other ESCOs through over-the-counter bilateral contracts. By 2012, the State Grid Corporation had created energy service companies in all 26 provinces and ten of the ESCOs were certified by the National Development Reform Commission and the Ministry of Finance. In the two years between 2010 and 2012, 116 energy management contracts, slated to deliver 667 GWh of savings, had been signed by ESCOs. Trial trading programs emerged in Beijing at the Environment Exchange Center (Regulatory Assistance Project, 2012).

This pilot white certificate market was put on hold after 2013 when China decided to do a cap-and-trade program that started with a pilot program in five cities and two provinces (Stavins, 2018). In December of 2017, China launched the national cap-and-trade trading platform; allowances will most likely be allocated in 2018, and the program will be fully operational in 2019. The first sector to be regulated will be the electric power sector, and then seven other heavy industries (iron and steel, non-ferrous metals, chemicals, petro-chemicals, paper, building materials, and civil aviation) will be regulated in later years (Harvey, 2017).

In its 13th Five-Year Plan and China Strategies for Revolutionizing Energy Production and Consumption (2016-2030), China has set ambitious energy-reduction targets for the years 2020 and 2030 that require both an energy intensity and total energy reduction. These targets are summarized in Figure 3.

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[8] Multiplied average VEEC price in December of 2017 of $19.6 AUD by 0.8136 metric tons of CO_2 (average grid emission factor for Australia)/MWh = $15.94 AUD/MWh. Then converted $15.94 AUD/MWh to $12.70 USD/MWh.

Figure 3: Summary of China's Energy Reduction Targets (IEA, 2017b).

	2020	2030
Energy Intensity Target	Primary energy consumption must be at or below 5 billion tons of coal equivalent (tce) or 40,705 TWh	Primary energy consumption must be at or below 6 billion tons of coal equivalent (tce) or 48,846 TWh
Energy Reduction Target	Ratio of energy use per unit of GDP must be reduced by 15% of 2015 levels	Non-fossil fuels must account for 20% of total energy consumption

Critics of the cap-and-trade system point out that by initially including only the electric power sector, energy efficiency is not sufficiently subsidized. Another pilot program called the Energy Use Right Trading that could address this gap in the current cap-and-trade program has been initiated in four provinces. This program would begin in 2020 and involves the trading of allowances for energy usage. It is not modeled off any existing program and will be a unique way of incentivizing energy efficiency. Initially there will not be direct double counting or overlap of the cap-and-trade system and the Energy Use Right Trading since the heavy industries that will be trading energy allowances will not be capped under the cap-and-trade system. However, after the cap-and-trade program is expanded, there will be overlap. Currently, regulators are considering converting the energy allowances (which will have units related to coal-equivalence instead of MWh) to carbon allowances (with units in metric tons of CO_2). The conversion will possibly be done using an average grid emission factor for the electrical grid where the energy allowance originates. This conversion could have the consequence of shifting energy reduction projects from areas where the grid is relatively clean with large hydro and other renewable facilities to areas where the coal dominates the electric power grid since energy allowances created in these coal-based locations will create more value in carbon allowances. Given the possible complications with running these two trading programs simultaneously, the government is somewhat hesitant to unroll the Energy Use Right Trading widely (Yang, 2016).

Denmark

Denmark has made energy efficiency a priority since the 1970s. The Energy Policy Agreement of 2008 required Denmark to reduce energy consumption by 2% in 2012 (Regulatory Assistance Project, 2012). Under an updated version of this Agreement in 2012, the target for energy savings is 2.6% for 2013 and 2014, and 2.96% for 2015-2020 (Energi Styrelsen, 2013). The fuels covered by this Agreement include electricity, natural gas, heating oil products, and district heating, and the obligated parties are distributors for electricity, natural gas, and district heating, with heating oil distributors participating voluntarily. Obligations are determined based on each entity's market share of the relevant fuel; about 50% of the obligation falls on electricity distributors (Regulatory Assistance Project, 2012). The market participants consist of 70 electricity grid operators, three natural gas distributors, ~400 district heating companies, and six oil companies (Energi Styrelsen, 2013).

The Danish market is dictated by the governmental target of 10.1 PJ (quadrillion Joules) per year from 2016-2020. Since the market has been in operation approximately 16.7 TWh[9] of electricity savings have occurred (Energi Styrelsen, 2013). In 2016, the average price was 49.6 øre/kWh ($79 USD/MWh) and the total volume of savings was 3,131,883 MWh. The price varied slightly by sector; for electricity network companies, it was 53.9 øre/kWh (or about $0.09 USD), for natural gas companies, it was 46.9 øre/kWh ($0.08 USD) and for district heating companies, it was 45.6 øre/kWh ($0.08 USD). Either the obligated entity or a third party can develop the energy reductions (Dyhr-Mikkelsen, personal correspondence, December 21, 2017).

France

France created a white certificate trading scheme under the Energy Policy Framework (POPE No. 2005-781) legislation with several phases from 2006-2009, 2011-2013, and 2015-2017. The targets for energy savings have been ramped up over these three periods, and the target was 700 TWh cumac for the three-year period, 2015-2017. The "cumac" in the target refers to cumulative savings. Each certificate, measured in kWh cumac, is valid for nine years, although it is discounted by 4% each year. The target refers to the cumulative savings that will be achieved by the certificates over their lifetime, and this target equates to 4.8% of annual electricity sales (IEA, 2017a and Rte-France, 2017).[10] The requirements are split among energy suppliers of electricity, gas, heating oil, LPG, heat, and refrigeration with the largest companies bearing the brunt of the reductions. Some of the regulated entities in the ETS also have white certificate obligations. Therefore, the white certificates generated from these ETS participants serve to lower their emissions, which makes it easier for them to comply with the EU ETS. Regulated entities can meet the requirements by educating customers about how to reduce energy consumption, providing incentives and rebates for energy-efficient equipment, and undertaking other measures. According to the policy, suppliers must then verify real reductions are occurring from these education campaigns. If objectives are not met, then suppliers can trade energy savings certificates. Non-compliance penalties of €.02/kWh apply (IEA, 2017a).

In the first phase when the target was 54 TWh cumac, fuel suppliers were not included, and 84% of reductions came from the residential sector. In the second phase, fuel suppliers were included, and the obligated entities had an oversupply of white certificates and surpassed the target of 345 TWh cumac. Information is not yet available showing if the 2017 target was met or exceeded. The program has resulted in 462 TWh cumac of savings, with 90% of those savings occurring in buildings (IEA, 2017c).

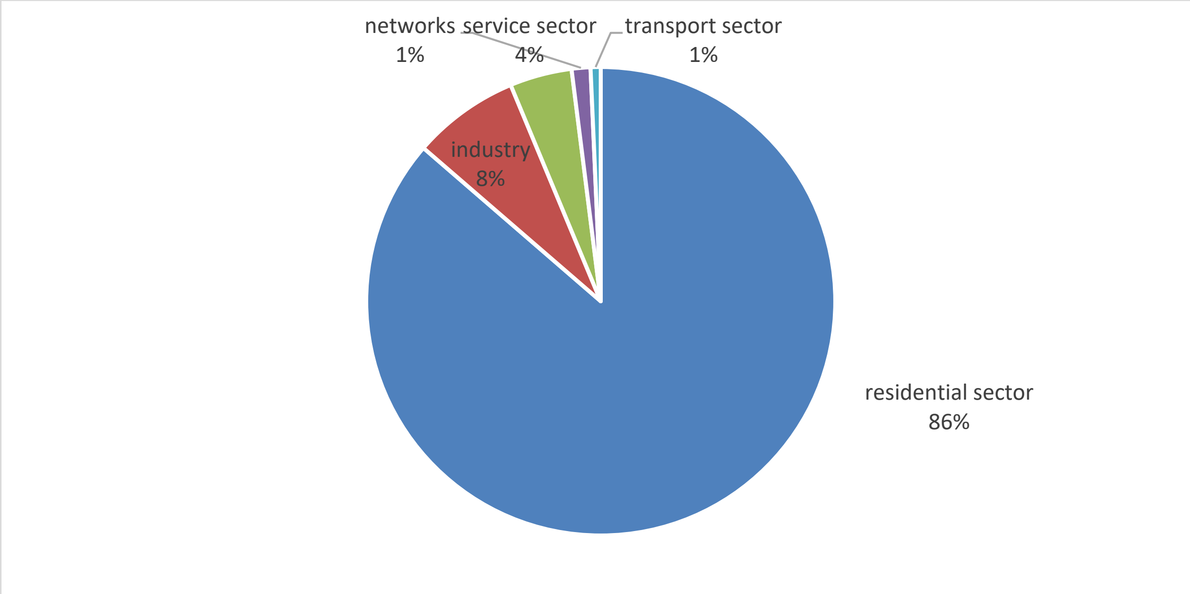
Over the three periods of operation, rules have been modified to simplify the system, standardize documentation for creation of certificates, and increase the transparency of the program. To date, limited trading has occurred as suppliers have preferred to implement the

[9] Annual commitment since 2012 = 10.1 PJ/year or 2.8 TWh/yr. Therefore, cumulative savings as of the end of 2017 are 16.8 TWh.

[10] 529.4 TWh is the total 2017 energy production in France. 700 TWh is the white certificate target for France for 2015-2017. So, 233.3 TWh (2017 annual white certificate target in France)/529.4 TWh (total 2017 energy production in France) = 0.44

projects themselves (Bertoldi, 2011). For the first phase of this market, the breakdown of energy savings by sector is shown in Figure 4.

Figure 4: Energy Savings by Sector in French White Certificate Program (Ministry of Ecological and Solidary Transition, 2016)



Italy

In Italy, a white certificate is not a MWh of electricity savings, but instead is equivalent to one metric ton of oil avoided (Pela, 2015). Using the average grid emission factor for the U.S. of 0.7 metric tons of CO_2/MWh generated, one can see that one white certificate on average nationally is equal to less than one metric ton of CO_2.[11] The amount of CO_2 in one metric ton of oil is three metric tons.[12] Therefore, one white certificate in Italy is equal to 4.3 U.S. white certificates.[13] This unit per metric ton of oil equivalent was selected to tie the white certificates to a primary source of energy, as opposed to the U.S. MWh definition for white certificates, which varies based on the resources that serve a certain grid. The fact that these definitions, and those from other countries, differ was not problematic for the Italians as they never envisioned their system to be fungible with other countries' white certificate schemes. Since ratepayers in Italy help support this system, Italians did not want the money for energy reductions leaving the country (Bertoldi, personal communication, November 27, 2017).

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[11] 1,640.7 lbs CO_2/MWh × (4.536 × 10-4 metric tons/lb) × 0.001 MWh/kWh = 7.44 × 10-4 metric tons CO_2/kWh (U.S. national weighted average CO_2 marginal emission rate, year 2016 data from U.S. EPA, 2018).

[12] 5.80 mmbtu/barrel × 20.31 kg C/mmbtu × 44 kg CO_2/12 kg C × 1 metric ton/1,000 kg = 0.43 metric tons CO_2/barrel (EPA, 2018). Assuming petroleum has a specific gravity of 0.88, 1 barrel = 158.9 liters. 1 barrel weighs: 158.9 liters * 0.88 = 139.9 kilograms 1000 kg/metric ton/ 139.9 kg = 7.1 metric tons. Therefore, there are a little over 7 barrels of petroleum in a metric ton. 7 barrels/ton of oil * 0.43 metric tons of CO_2/barrel = ~3 metric tons of CO_2/ton of oil (Fogt, 2003).

[13] 5.80 mmbtu/barrel × 20.31 kg C/mmbtu × 44 kg CO_2/12 kg C × 1 metric ton/1,000 kg = 0.43 metric tons CO_2/barrel (EPA, 2018). Assuming petroleum has a specific gravity of 0.88, 1 barrel = 158.9 liters. 1 barrel weighs: 158.9 liters * 0.88 = 139.9 kilograms 1000 kg/metric ton/139.9 kg = 7.1 metric tons. Therefore, there are a little over 7 barrels of petroleum in a metric ton. 7 barrels/ton of oil * 0.43 metric tons of CO_2/barrel = ~3 metric tons of CO_2/ton of oil (Fogt, 2003). 3 metric tons of CO_2/metric ton of oil * 1 MWh/0.7 tCO_2 = 4.3 MWh/metric ton of oil in the U.S.

Internationally, the country with the most experience trading white certificates is Italy. Figure 5 shows how the energy reductions made in Italy far surpass other European countries. While there are other energy efficiency programs in each of these countries, white certificates comprise 60% of the reductions made in Italy, demonstrating how important this system is to the country's program. This trading has the lowest cost/saving ratio as compared to all other energy efficiency programs in Italy (EPATEE, 2017).

Figure 5: Comparison of Energy Reductions Made through European Energy Efficiency Obligation Schemes (Nadel and others, 2017)

	Time Period	Final Energy Savings per year (k metric tons of oil equivalent)	Sector
United Kingdom	2008-2012	237	Household sector
Denmark	2015	291	All sectors excluding transport
France	2011-2013	377	All sectors
Italy	2015	500	All sectors

In 2001, the Italian Ministry of Industry established an obligation for gas and electric distribution companies with more than 100,000 customers (50,000 since 2007) to achieve specific annual energy savings targets during a five-year period from 2005-2009. Italy's Regulatory Authority for Electricity and Gas (AEEG) designed the program, and the Italian scheme for energy-savings certificates (ESCs) became operational in January 2005 (Hamrin, Vine & Sharick, 2007). The tradable white certificate scheme was selected because the Italians wanted to allow for cost containment and had observed sulfur dioxide trading schemes in the U.S. operating successfully to keep compliance costs down. Prior to this program, Italy did not have much experience in energy efficiency programs and was primed to adopt a new program throughout the country. Also, Italy did not have a developed ESCO sector in this area (Vine, personal communication, December 4, 2017).[14]

Italy updated its legislation in Decree 28/12/2012 to meet the E.U. Energy Efficiency Directive 27 of 2012 of 1.5% energy reductions annually. In 2017, Italy again updated its legislation with a Ministerial Decree 11/01/2017 that is significantly more stringent in terms of the targets required and monitoring and verifying energy savings. The 2014 Decree required that 7.6 million toe (88.39 TWh) by 2017 be reduced and the new decree extends targets to 2020 and calls for 11.19 million toe (130.14 TWh) of reductions by that date. This target equates to 39.4% of Italy's overall electricity sales (Ministerial Decree 11/01/2017 and Terna Group, 2013).[15] Throughout this paper, key aspects of that new decree will be highlighted where appropriate, as it relates to white certificate lifetime, additionality, and monitoring and verification.

[14] This is in sharp contrast to a place like California, which by 2005 had energy efficiency programs in place for thirty years and was not interested in adopting a new program to incentivize this sector. In addition, after AB 32 passed in 2006, California was in the process of rulemaking surrounding the new cap-and-trade legislation. For these reasons, the state of California was not an adopter of a white certificate trading program (Vine, personal communication, December 4, 2017).

[15] 2020 target is 11.19 million toe, which equals 130,139 GWh.
130,139 GWh (2020 target)/330,043 GWh (total electricity consumption in 2013) = 0.394.

The Italian white certificates are supplied by electricity and gas distributors, companies with energy managers, companies with certified ISO 50001 (energy management certification), and Energy Service Companies (ESCOs) who typically fund the cost of energy efficiency upgrades and take their payment from the energy savings the client experiences. The market is managed by GME (Gestore dei Mercati Energetici SpA), which monitors prices and trades. GSE (Gestore di Servizi) evaluates projects submitted by ESCOs and authorizes the projects to be sent to GME if they are acceptable. The market is regulated, and rules are set by AEEGSI (The Italian Regulatory Authority for Electricity, Gas, and Water). A fine is levied if 60% of a utility's obligation is not met, and the deficit of white certificates is applied to the obligation for the next year (Pela, 2015).[16]

In 2015, ESCOs supplied 78% of all certificates while generators supply only 4.7% of them. One distributor had 50% of the compliance obligation in Italy (Pela, 2015). The civil sector, which comprises hospitals, small businesses, schools, and homes, is less profitable for ESCOs since these projects involve aggregating many homes and involve huge amounts of monitoring and installation in many locations; therefore, this sector makes up only 32% of overall market (Bertoldi, personal communication, November 27, 2017 and Pela, 2015).[17] The industrial sector dominates the market with projects that involve installation of more efficient equipment for cooling, drying, burning, and melting, energy optimization, and improved plant design layout, while heat recovery through cogeneration plants follow other rules according to primary energy saving calculations (Pela, 2015).

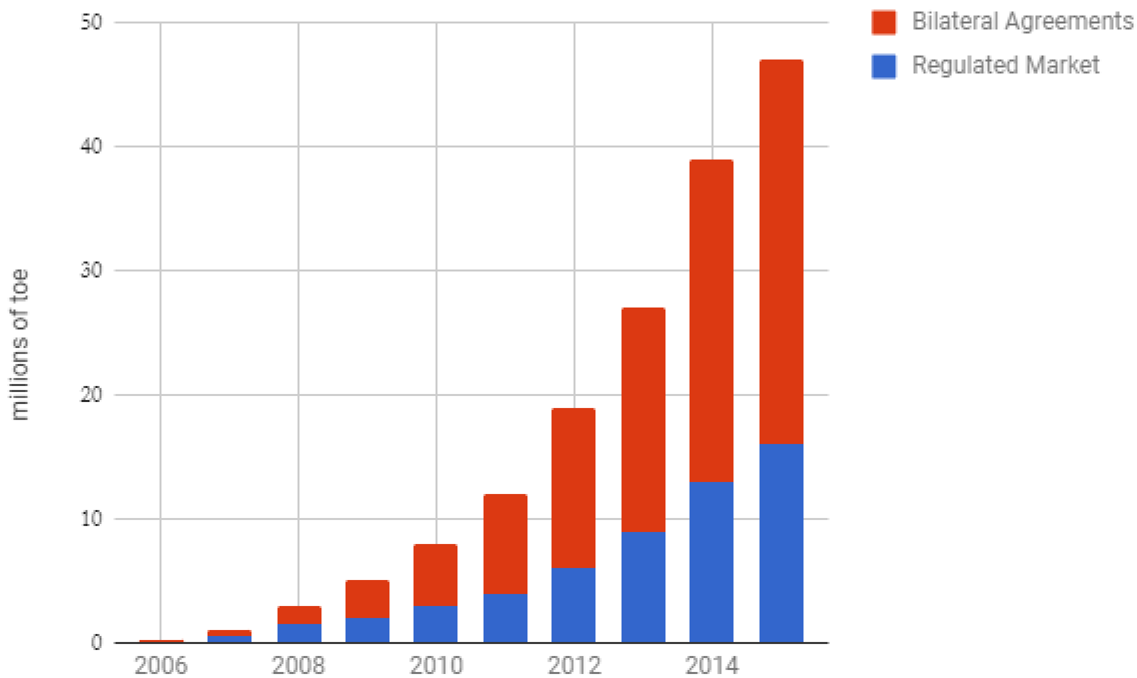
A unique aspect of the Italian white certificate regulations is that regulated entities must fulfill 60% of their energy reductions for the national target through trading of white certificates and transportation is a part of this white certificate market (Article 7 of the E.U. Energy Efficiency Directive). This mandate creates a guaranteed market for tradable white certificates. Italy's trading overwhelms the trades made in the U.S. market with 47 million white certificates traded in total through this program (Pela, 2015); however, it should be noted that the total number of white certificate trades is more than the toe reduction targets for Italy because of the *tau* factor of 2.5 that was applied to these projects prior to 2017. The total toe of energy savings of the program is 23.8 million; equating to 102 TWh of trades (See Figure 7 for all U.S. trades.) The total U.S. volumes of white certificates traded in all states is just over 17 TWh (See Figure 7). Of the Italian white certificates traded, 35% were traded through a regulated market while 65% were traded through bilateral agreements made between two parties and not on an exchange (Pela, 2015). The market price prior to 2015 was ~€105/toe, although the price fluctuated with the market, and there is a slight difference between market prices and bilateral agreement prices. Since 2015, the price of a white certificate has continuously increased, up to at €300-350/toe in 2017 due to the fact that many of the cheapest energy reductions had

[16] Since 2015 there is a fixed fee per project, in the range €100-2,500 depending on the size and type of project, and variable fee of €1.1 per issued certificate for projects above 100 certificates per year. There is also a €0.1 fee to register projects that both the buyers and sellers pay (EPATEE, 2017).

[17] However, there is a large tax credit from the Energy Efficiency Tax Rebate Program in Italy that benefits the residential and buildings sector with a tax credit of 65% (usable over 10 years) of the project costs (IEA, 2016).

already been developed, leaving only more expensive options. This Italian price equates to $53.7 USD/MWh (Brander and others, 2011).[18]

Figure 6: Cumulative White Certificates Sold in Italy (Pela, 2015)



Poland

Poland had a short-lived white certificate market from 2013-2016. It was part of the Energy Efficiency Obligation Scheme to meet the 2014 E.U. mandate of 1.5% emission reductions annually, but it had many complicated design features with sub-categories of savings targets. Also, the short time horizon of the market prevented it from succeeding; just 3.8% of the expected savings were bid into the initial auction for this market (Nadel and others, 2017).

United Kingdom

In the U.K., the 2008 Climate Change Act enabled the Carbon Reduction Commitment (CRC) Energy Efficiency Scheme, which incentivizes energy efficiency in large energy users with over 6,000 MWh of electricity usage annually. This CRC Scheme is one of several programs to promote energy efficiency and reduce greenhouse gas emissions in the U.K. This type of energy-saving obligation started in 2002 with the Energy Efficiency Commitment (EEC) which ran from 2002-2005. The second phase ran from 2005-2008, and the third phase was called the Carbon Emission Reduction Target (CERT), which later became the Energy Company Obligation (ECO). The commonality in these programs was that they applied to energy suppliers (Johnson

[18] 3 metric tons of CO_2/metric ton of oil (see footnote 8 for the origin of this assumption) * 1 MWh/0.4 tons of CO_2 (average grid emission factor in Italy) = 7.5 MWh/metric ton of oil in Italy
325 € (average of 300 and 350 € price quoted)/toe / 7.5 MWh/ metric toe = 43.3 Euros = $53.7 USD

and others, 2013). In contrast, the CRC Scheme, which is the only one of these schemes that allows trading, applies to energy users. Collectively these supermarkets, banks, governmental buildings, and other businesses comprise 10% of the U.K.'s greenhouse gas emission, and by 2027, the CRC Scheme is expected to result in 16 million metric tons of reductions, which equates to 1.57% of the U.K.'s electrical sales if the average grid emission factor for the U.K. is used to convert metric tons of CO_2 to MWh (U.K. Committee on Climate Change, 2016, U.K. BEIS, 2017a and 2017b)[19] The CRC Scheme is administered by the Environment Agency on behalf of the Department of Energy and Climate Change. The Environment Agency runs the U.K.-wide registry, and handles registration, reporting, and allowance sales (U.K. Committee on Climate Change, 2016).

Participants of this system purchase allowances in auctions or through a fixed price set by the government; this price was fixed at £12/t CO_2 for the first sale. So, the white certificates in this market are not in terms of energy reduced, but instead are in terms of carbon dioxide avoided. These certificates are converted to metric tons of CO_2 using approved emission factor conversions. This market acts as a cap-and-trade system where participants purchase allowances equal to their emissions and then surrender them at the end of the compliance period. Allowances must equal the entity's greenhouse gas emissions, which are reported annually. Not every project is audited for its emissions reported under the system of monitoring and verification set up by the Environment Agency. Spot checks are done, but entities self-certify emissions in annual reports.[20] In 2016, allowances were trading at £16.9/tCO_2 ($8.43 USD/MWh) (U.K. Committee on Climate Change, 2016 and U.K. BEIS, 2017a),[21] and there were 2000 participants in the program (U.K. Department of Energy and Climate Change, 2014).[22]

Figure 7 below compares the operational white certificate schemes in terms of reduction targets, volumes traded, and price of certificates. It is evident from this table that the programs with more aggressive targets are costlier per certificate since these are often the programs that have been in operation the longest and the cheapest reductions have already been made within these territories. It is also apparent from this table that the reduction targets in France and Italy are far more aggressive than in other places.

[19] Total electricity generated in the UK in 2016 was 339.4 million toe. There are 3 metric tons of CO_2/toe (see footnote 12 for calculations related to this assumption). 339.4 million toe * 3 metric tons of CO_2/toe = 1018.2 metric tons of CO_2 (total CO_2 from generation in 2016)
16 million metric tons of CO_2 (2027 target)/ 1018.2 million metric tons of CO_2 (total CO_2 from generation) = 0.0157

[20] Spot checks are carried out by the Scottish Environment Protection Agency (SEPA) in Scotland, the Department of the Environment Northern Ireland in Northern Ireland, and Natural Resources Wales (NRW) in Wales (U.K. Committee on Climate Change, 2016).

[21] 2016 allowances traded at £16.9/metric ton of CO_2. £16.9 * 0.35156 metric tons of CO_2/MWh (U.K. average grid emission factor) = £5.94/MWh. When converted to USD, this is $8.43/MWh.

[22] This department was formally reorganized in 2016 to the Department for Business, Energy and Industrial Strategy.

Figure 7: Comparison of White Certificate Schemes in US and Abroad

Location	Reductions Targets	Volumes Traded Since Inception of Program (converted to units of electricity)	Price of Certificate (all prices are converted to USD)[23]
Connecticut	1.12% of electricity sales (DSIRE, 2017b)[24]	16.78 TWh (NEPOOL GIS, 2017)[25]	$10/MWh (Nelson, 2012; Holt, 2010)
Michigan	15% of electricity sales by 2021 from renewables or met through efficiency (DSIRE, 2017a)	N/A – credits not tracked separately from RECs	N/A
Nevada	Up to 4% of electricity sales can be met through energy efficiency (DSIRE, 2016)[26]	None traded, but NV Energy has used ~3.4 GWh of reductions towards the program (NV Energy, 2017)	N/A
Pennsylvania	10% of electricity sales by 2021 (Pennsylvania PUC, n.d.) [27]	94 GWh (PJM Interconnection & Environmental Information Services, n.d.)[28]	$0.16/MWh as of 2017 (PJM Interconnection & Environmental Information Services, n.d.)
Australia - New South Wales	8.5% of electricity sales by 2019 (IPART, 2016)	21.6 TWh (Green Energy Markets, 2017)	$17.47/MWh as of November 2017 (Green Energy Markets, 2017)
Australia – Victoria	2% of electricity sales in 2020 (Essential Services Commission, n.d., Sustainable IT, 2015 and Dept. of Industry, Innovation, and Science, 2016)[29]	53.46 TWh by 2020 (Essential Services Commission, n.d. and Sustainable IT, 2015) [30]	$12.39/MWh (Essential Services Commission, n.d. and Sustainable IT, 2015)[31]

[23] All currency conversions were made on February 15, 2018.
[24] By 2020, 28% of CT's electricity must be renewable, and 4% of this 28% must be from energy efficiency. So, the total energy efficiency requirement is 1.12%.
[25] Total Tier II RECs from NEPOOL GIS data.
[26] This is from the state RPS. Energy efficiency can comprise 20% of the 20% RPS. Therefore, 0.2*0.2 = 0.04.
[27] Included in this category with energy efficiency is large-scale hydro, municipal solid waste, and wood pulping.
[28] Total GWh gathered from PJM GATS data of Tier II energy efficiency credits.
[29] 1410 PJ of total energy consumption in Victoria = 3.9 x 10^8 MWh
3.9 x 10^8 MWh * 0.8136 t CO_2/1 MWh (average grid emission factor for Australia) = 3.12 x 10^8 t CO_2
6.5 x 10^6 total VEECs/3.12 x 10^8 t CO_2 (total emissions from energy consumption in Victoria) = 0.02
[30] Authors used the 2009-2011 target of 2.7 million VEECs annually plus the 2012-2017 target of 5.9 million VEECs annually to find the total cumulative VEECs = 43.5 million VEECs. Then, 43.5 million tons of CO_2 * 1MWh/0.8136 metric tons of CO_2 (average grid emission factor of Australia) = 53.46 TWh.
[31] Multiplied average VEEC price in December of 2017 of $19.6 AUD by 0.8136 metric tons of CO_2 (average grid emission factor for Australia)/1MWh = $15.94 AUD/MWh. Then converted $15.94 AUD/MWh to $12.70 USD/MWh.

Denmark	2.96% annual electricity savings (Energi Styrelsen, 2013)	16.7 TWh[32]	$79/MWh (Dyhr-Mikkelsen, personal correspondence, December 21, 2017)[33]
France	4.8% of annual electricity sales (IEA, 2017a and Rte-France, 2017)[34]	51.3 TWh (IEA, 2017c)[35]	$4.32/MWh (Emmy, 2018)[36]
Italy	18.13% of electricity sales (Ministerial Decree 11/01/2017 and Terna Group, 2013)[37]	180 TWh (Roteroti, 2017)[38]	$53.7/MWh (Brander and others, 2011)[39]
United Kingdom	1.57% of electrical sales or 16 million metric tons by 2027 (U.K. Committee on Climate Change, 2016, U.K. BEIS, 2017a and 2017b)[40]	N/A	$8.43/MWh (U.K. Committee on Climate Change, 2016 and U.K. BEIS, 2017a)[41]

[32] Annual commitment since 2012 = 10.1 PJ/year or 2.8 TWh/yr. Therefore, cumulative savings as of the end of 2017 are 16.8 TWh.
[33] Converted average price of 49.6 øre/kWh for 2016 to USD/MWh.
[34] 529.4 TWh is the total 2017 energy production in France. 700 TWh cumac is the white certificate target for France for 2015-2017. So, the target for 2017 is 700 TWh cumac/3 = 233.3 TWh cumac and these certificates generated are valid for 9 years. So, 233 TWh cumac/9 years = 25.88 TWh (2017 annual white certificate target in France)/529.4 TWh (total 2017 energy production in France) = 0.048
[35] This statistic is accurate as of 2016. 462 TWh cumac/9 years (lifetime of certificates) = 51.3 TWh.
[36] .0035 Euros /kWh = 3.5 Euros/MWh and then converted to USD.
[37] 2020 target is 11.19 million toe, which equals 130,139 GWh. 130,139 GWh * 0.46 (average efficiency of power sector in Italy) = 59,863 GWh. 59,863 GWh (2020 target)/330,043 GWh (total electricity consumption in 2013) = 0.1813
[38] 24 million toe cumulative energy savings from white certificates * 3 metric tons of CO_2/metric ton of oil *(1 MWh/0.4t CO_2) = 180 TWh. Energy savings, not actual white certificates sales, were used to make this conversion to TWh since white certificate sales had a 2.5 multiplication factor applied to them prior to 2017, and would prevent an accurate conversion to TWh.
[39] 3 metric tons of CO_2/metric ton of oil (see footnote 8 for the origin of this assumption) * 1 MWh/0.4 tons of CO_2 (average grid emission factor in Italy) = 7.5 MWh/metric ton of oil in Italy
325 € (average of 300 and 350 € price quoted)/toe /7.5 MWh/ metric toe = 43.3 Euros = $53.7 USD
[40] Total electricity generated in the UK in 2016 was 339.4 million toe. There are 3 metric tons of CO_2/toe toe (see footnote 12 for calculations related to this assumption). 339.4 million toe * 3 metric tons of CO_2/toe = 1018.2 metric tons of CO_2 (total CO_2 from generation in 2016)
16 million metric tons of CO_2 (2027 target)/1018.2 million metric tons of CO_2 (total CO_2 from generation) = 0.0157
[41] 2016 allowances traded at £16.9/metric ton of CO_2. £16.9 * 0.35156 metric tons of CO_2/MWh (U.K. average grid emission factor) = £5.94/MWh. When converted to USD, this is $8.43/MWh.

Box 2: Cost Comparison of White Certificate Programs

There is a need for a comprehensive study on the cost of white certificate trading programs internationally to determine if trading is the most economically-favorable choice for achieving energy reductions if used in future markets. Data for comparing costs across all countries is not available, and the graphs below represent the data that has currently been compiled. Figure A-1: Cost of Conserved Energy in White Certificate Programs (Bertoldi, 2011)

Figure A-1: Cost of Conserved Energy in White Certificate Programs (Bertoldi, 2011)

When comparing these tradable program costs across countries, it is important to remember that higher program costs, such as in Denmark, may be the result of a variety of program considerations and market opportunities. Programs with more stringent protocols for monitoring and verification may incur higher costs due to third party intervention. However, these programs also may generate the most additional energy savings, thereby contributing to climate change and energy reduction goals more than other programs. Denmark is also a smaller country with more limited opportunities for reductions. Market stringency will have a bearing on the cost of reductions. Existing markets with less stringent rules will be able to capture the cheaper "low-hanging" fruit of energy reductions for longer—this is also applicable to U.S. states that have put off adopting renewable portfolio standards. Also, the U.K.'s EEC-1 and 2 were energy reductions on energy suppliers and did not involve trading, so any cost savings due to trading would not be reflected in the figures above (Johnson and others, 2013). Therefore, it is difficult to compare "apples to apples" in the cost estimates of these markets. Finally, these cost estimates from 2011 are now somewhat dated and should be redone. Expansion of these programs is unlikely based on existing studies showing its cost effectiveness will occur.

Box 2: Cost Comparison of White Certificate Programs (continued)

Figure A-2: Annual Administrative Costs of Selected White Certificate Programs (Bertoldi, 2011)

Some countries are continuously monitoring their programs to make sure that the policies in place are achieving their goals in a cost-effective way. For example, Denmark conducts a study into the costs of the 25 companies whose costs were in the 5% highest category. They also look at some of the companies with the lowest costs with the goal of learning what determines the costs in the market and how they can be lowered (Dyhr-Mikkelsen, personal correspondence, December 17, 2017). Perhaps this type of analysis should be done across countries to learn from these fledgling white certificate markets and pass this knowledge on to those countries like Ireland, the Netherlands, Portugal, Romania, and Bulgaria who are considering implementation of white certificate programs.

Conclusion to Section I

While trading of white certificates in the U.S. has not taken off, it has been successful in other countries such as Italy, France, and Australia where there are significant volumes traded. Some U.S. programs, which are carveout requirements of a state-level Renewable Portfolio Standards, are intentionally being phased out, as is the case in Nevada. In other places, white certificate programs are being made more stringent, as in Italy where the 2013, 2014, and 2017 changes to the white certificate program have caused the certificate price to soar from 100 €/toe to 350 €/toe. In Australia, the white certificate programs in Victoria and New South Wales have been carefully designed and make significant contributions to the state energy reductions. In Denmark, the U.K., and France, white certificate programs exist, but volumes of trades and prices remain significantly lower than those in Italy, and little information has been published on these systems. China and Poland had short-lived white certificate trading schemes, but they have since abandoned these programs in favor of other policies to reduce energy usage. In general, the programs that have more stringent energy reduction goals have higher cost of white certificates since the cheapest forms of energy reduction have already been developed. While white certificate markets have been attempted in many parts of the world, they have only thrived in some areas. The next section will attempt to answer why white certificates have become the policy instrument of choice for energy reductions in some places by analyzing how each market has handled the challenges that face white certificate trading.

Section II: Challenges to Trading White Certificates

This section will address the major challenges to trading white certificates, identify why these obstacles exist, and then discuss how successful white certificate markets have addressed these potential problems. The challenges that face white certificate markets are similar to those that have plagued offset and REC markets, and connections to these markets and lessons learned will be highlighted where appropriate. Also, when an appropriate comparison to a white certificate market can be made, how these challenges have been approached will be described.[42] The challenges that will be addressed include the definition of a white certificate (including whether it is real, additional, permanent, verifiable, and enforceable), who owns them, and how they are tracked.

One of the first major challenges to white certificates is the definition, which varies by technology and unit, based on where it originates. Inconsistency in this definition prevents widespread trading. Adding to this situation, the certificates must be real, additional, permanent, verifiable, and enforceable to be considered valid. The "real" requirement is challenging when these programs have overlapping greenhouse gas legislation. Similar to this "real" requirement, the certificates must also be considered "additional," which involves assuring that the white certificate program is not incentivizing projects that would have occurred in a business-as-usual situation. The criterion of being "permanent" is difficult as the permanence of these white certificates varies by technology, and the number of years credited to particular white certificates is dramatically different based on the program where it exists. Through proper monitoring and verification, each program ensures that the white certificates are verifiable and enforceable, and these programs differ greatly based on their location. Each white certificate must have an ownership trail and be tracked effectively, but ownership gets muddled based on who paid for the equipment upgrade. Furthermore, the tracking systems are not always transparent or open to the public, making trades hard to follow. How each market handles these challenges will be illuminated in the section below.

Definition of White Certificates

One major issue facing the establishment of a white certificate market in the U.S. or globally is the fact that there is not one singular, clear definition. Even the name of this instrument differs by state and country, as they have been named under different pieces of legislation. Figure 8 shows examples of how the definition varies worldwide.

[42] Given the relative newness of these markets, it is not possible to describe how each market has approached each challenge. Therefore, the analysis will not describe every country's program in each of this section's subsections.

Figure 8: White Certificate Definition and Name by Location

Location	Name	Definition
Connecticut	Type III REC or Conservation Certificate	One MWh of electricity saved from one of the following: "(1) customer-sided CHP systems, with a minimum operating efficiency of 50%, installed at commercial or industrial facilities in Connecticut on or after January 1, 2006; (2) electricity savings from conservation and load management programs that started on or after January 1, 2006, and (3) systems that recover waste heat or pressure from commercial and industrial processes installed on or after April 1, 2007." (DSIRE, 2017b)
Nevada	Portfolio Energy Credits	One kWh of electricity "(1) implemented after January 1, 2005; (2) sited or implemented at a retail customer's location; and (3) partially or fully subsidized by the electric utility. The measure must also reduce the customer's energy demand (as opposed to shifting demand to off-peak hours)" (DSIRE, 2016).
Pennsylvania	Tier II RECs	One MWh from (new and existing) waste coal, distributed generation, demand-side management, large-scale hydro, municipal solid waste, wood pulping and manufacturing byproducts, useful thermal energy, and integrated gasification combined cycle coal technology (DSIRE, 2018).
Sterling Planet Clients	White Tags	One MWh of electricity savings or 1000 cubic feet of natural gas saved (Sterling Planet, 2013).
Australia - New South Wales	Energy-Saving Certificates	One MWh of electricity saved or 0.39 certificates per MWh or around 0.11 certificates per Gigajoule saved (NSW Government, 2015).
Australia – Victoria	Victorian Energy Efficiency Certificates	One metric ton of CO_2 savings (Essential Services Commission, n.d.).
Denmark	Energy-Saving Certificate	One kWh of energy saved from approved methods in the electricity, natural gas, heating oil products, and district heating sectors (Energi Styrelsen, 2013).
France	White Certificates	One kWh of electricity savings (IEA, 2017a).
Italy	White Certificates	One metric ton of oil equivalent (Pela, 2015).
United Kingdom	Energy Efficiency Obligations	One metric ton of CO_2 savings (U.K. Committee on Climate Change, 2016).

Not only do the units for white certificates differ, but the types of technologies that are acceptable for generation of white certificates differ by program location. The lack of a common unit and definition prevents these fledgling programs from ever being fungible internationally as occurs within the EU Emission Trading Scheme. One of the biggest benefits of these tradable white certificates is that they allow for cost containment as market participants can trade certificates to meet goals instead of attempt to meet all energy reduction targets on-site; however, cost containment is limited when international programs are not fungible with each other and individual markets have fewer players and opportunities for energy savings. In Italy, trading was not considered a priority when setting up the system, but in 2016, there was a workshop in Brussels hosted by the European Commission to discuss trading between Italy and France.

In considering the definition of which technologies qualify for white certificates, the goal of the energy efficiency legislation must be articulated. If the goal is to make greenhouse gas reductions at the cheapest cost, then allowing any type of energy efficiency or combined heat and power technology could be allowed. The cheapest technologies at the residential level tend to be lighting retrofits, followed by insulation. Alternatively, if the goal of energy efficiency legislation has a social justice component and is meant to help distribute the benefits of access to lower electricity and heat bills to low income populations, then weatherization of mobile homes might be a preferred project. Just as RPSs have carveouts for certain technologies like solar energy, perhaps future energy efficiency legislation will have requirements that a portion of the energy reductions must be fulfilled by certain technologies that may not be the lowest cost option to meet greenhouse gas reduction goals. Trading of white certificates without carveouts for certain technologies would lead to the most cost-effective reductions being made first, which would exclude more expensive projects.

There has been an effort to create a universal, U.S. definition of a white certificate. Many experts in the field thought that a market for MWh savings would be as popular as a market for MWh generated from renewables, especially after Amory Lovins of the famous Rocky Mountain Institute had coined and promoted the idea of the “Negawatt,” the Watt that was never used (Lovins, 1985). Before RECs gained their popularity in the voluntary market, and were accepted by state legislatures in RPSs, it was necessary for them to be clearly defined. In 1997, Green-e was created from the Center for Resource Solutions to develop a standard for renewable energy certificates (RECs). The Green-e standard specifies the types of technologies that are eligible for certification, the year when the generation facility must have been constructed, the types of eligible customers, and other details of the generation (Center for Resource Solutions, 2017). Both the compliance and voluntary REC markets experienced enormous growth in the early 2000s, stimulated by the emerging state Renewable Portfolio Standards in the compliance realm and the EPA’s acceptance of RECs for their Green Power Partner Program, which allowed schools, non-profits, businesses, and industrial facilities to make voluntary commitments to purchase green power. The general public became aware of RECs also as REC marketers sprung up, and they became a popular way to try to reduce one’s impact on the environment; many saw them as a way to reduce their carbon footprint. Voluntary markets grew by 500% between 2003 and 2008 (Cook & Karelas, 2009). By 2016, “The voluntary green power market [accounted] for about 28% of all U.S. renewable energy sales” (O’Shaughnessy and others, 2017).

In the early 2000s, many market observers thought that white certificates would have the same success as RECs. Energy efficiency was seen as something that people within their own territories could achieve on their own. No special resources like excellent wind, solar, hydro, or biomass were needed to implement efficiency measures; therefore, purchasing credits for efficiency measures taken elsewhere was not desirable to customers. Compounding this situation as of December 2017 is that the cost of renewable energy continues to fall, making it close to the price of cheap energy efficiency measures. The American Council for an Energy-Efficient Economy (ACEEE) did not endorse these white certificates, and no major certifying body was interested in creating a standard for them. Green-e considered creating a standard for white certificates; however, unlike RECs where a sale could allow a community-based wind farm to go in the ground, there was no charismatic story associated them. White certificates simply lower the investment threshold to make the technology financially viable (Martin, personal communication, November 8, 2017). The Environmental Resources Trust also began development of a standard (Barbour, personal communication, November 10, 2017). However, no organization followed through with the creation of a standard for white certificates because of difficulties with the public perception of this intangible commodity and challenges related to what is often termed as the “Big 5” in the world of carbon offsets—whether the white certificate is **real, additional, permanent, verifiable, and enforceable** (Gero, 2009). Each of these characteristics will be described in turn.

Real

Ensuring that a white certificate is real would necessitate that it had not been double-counted, since counting the same reduction twice would not meet greenhouse gas or energy reduction goals. The design of future federal greenhouse gas legislation has a large bearing on whether or not a white certificate is deemed “real.” Many critics of policies to promote energy efficiency or credit electricity savings claim that these programs are unnecessary where cap-and-trade schemes exist. The logic of this argument is that the cost of electricity under a cap-and-trade scheme will include the price of carbon, and the market will naturally incentivize technologies that reduce electrical consumption. These critics also claim that white certificates could be double-counted in a territory where electric power producers are responsible for reductions since any use of energy-efficient technology will help either a generator or industrial facility that is capped meet its emissions targets. If the white certificates are sold from this reduction, then this would constitute a case of double counting (Nadel and others, 2017).

However, others make the counterargument that energy efficiency technologies need more of a direct incentive, especially since some emerging carbon markets like the Regional Greenhouse Gas Initiative (RGGI) have not had the effect of increasing demand for energy efficient technologies since the price of allowances is so low, at $3.80 (as of December of 2017) (RGGI, n.d.). The problem of double counting energy efficiency under a cap-and-trade system is similar to how renewable energy is counted in RGGI. In a cap-and-trade system where generators must purchase or receive allowances based on their historical emissions, zero-emission renewable energy generation serves to meet increasing demand without requiring generation facilities to purchase allowances, invest in carbon mitigation technologies, or make expensive equipment upgrades that would increase the efficiency of the plant and decrease carbon emissions. Selling voluntary RECs in a system such as this has no meaning since the renewable energy may not have reduced greenhouse gas emissions, but instead just helped regulated entities serve growing demand. In the absence of these voluntary REC sales, regulated utilities would have made reductions of their own or purchased allowances. To remedy this problem, RGGI states have created a set aside or amount of allowances "taken off the top" in the name of renewable energy. RECs sold in the voluntary market are converted to CO_2 savings using appropriate grid emission factors, and allowances equal to the CO_2 savings are retired from this pool permanently (RGGI, 2007). In a similar way, a set-aside could be established for energy efficiency under a cap-and-trade system in order to make sure that double counting of one emission reduction did not occur.[43]

Ironically, in Italy where large industrial and commercial clients are subjected to the regulations under the E.U.'s Emission Trading Scheme (ETS), the largest worldwide white certificate-trading program exists. There is the possibility that a company required to reduce its emissions to comply with the E.U. ETS could make reductions to comply with its ETS goals and then sell the same reduction in the form of a white certificate that could be used for compliance purposes. In this way, double counting of the same certificate could occur. Double counting could occur in any country with a cap-and-trade system for greenhouse gases that allows covered entities to generate white certificates. This type of double counting is something that the market manager GSE spot checks for but the design of the system is such that efficient boilers and other energy efficiency technologies installed anywhere in the E.U., including Denmark, France, and the U.K., will have the effect of helping entities regulated under the ETS to meet their targets (EPATEE, 2017). So, crediting any activity to reduce emissions under a cap could be seen as double counting as it makes it easier for those generation facilities to meet targets. It is possible that market managers in Italy have been unconcerned with double counting because they think the E.U. ETS, with an allowance price of €7.14 per metric ton of CO_2 (on December 8, 2017), has been too weak to incentivize much energy efficiency (EEX, 2017). The low value of the European Union Allowance, which is equal to one metric ton of CO_2, versus the €300-350 per metric ton of oil (equal to 3 metric tons of CO_2 when combusted[44]) of funding that the white certificate program in Italy provides, is pronounced. Perhaps, when the ETS becomes more stringent, the Italians may reconsider this overlapping of subsidies and double counting of emission and energy reductions.

Within the U.K., critics argue that double counting of the same emission reduction occurs since this system is overlapped by the European Union Emission Trading Scheme (E.U. ETS). However, at this point, projects that are eligible for white certificates in the sector fall below the threshold for E.U. ETS, and the U.K.'s Committee on Climate Change asserts that no double counting between the two programs exists (U.K. Committee on Climate Change, 2016; Barrett, personal correspondence, January 9, 2018).

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[43] It is important to note that direct double counting of white certificates and allowances by the same entity does not occur because only fossil fuel-based electric power generators with over 25 MW of capacity are regulated in the RGGI market.

[44] 8.887 × 10-3 metric tons CO_2/gallon of gasoline x 317 gallons/metric ton of oil = 2.813 metric tons of CO_2 per metric ton of oil (EPA, 2018).

In Denmark, the savings realized in a given year may be kept for the full period of the requirement, which currently runs from 2016-2020. For certificates created under a capped sector, a calculation corrects for the lifetime of these white certificates to prevent double counting (Energi Styrelsen, 2013). Also, the Danish Energy Agency monitors the white certificate program to make sure that double counting of reductions from that program and other incentive programs for purposes of fulfilling the national energy efficiency targets and the E.U. energy efficiency directive does not occur (Dyhr-Mikkelsen, personal correspondence, December 21, 2017).

In France, the white certificate scheme covers all energy suppliers, including electricity which is also covered under the EU ETS. White certificates created by electric distribution companies decrease the amount of fuel that must burn to create electricity, thereby reducing the amount of allowances that electricity providers need to hold. White certificate regulators do not see this as double counting because one commodity is an energy savings, while the other represents emissions released (Trauchessec). However, the reality is that the white certificate is essentially credited twice, once directly through a sale, and once indirectly as it makes it easier for the electricity companies to comply with the ETS.

In Australia, there was a Greenhouse Gas Reduction Scheme which ran from 2003-2012. Under this scheme, there was no double counting as there was a "Demand-side Abatement Rule," which allowed for crediting of energy efficiency activities, but did not allow for projects to earn credit under both this Rule and the white certificate program. The Demand-side Abatement Rule was the prototype for the current Energy Savings Scheme, which started in 2009, and grandfathered in some Demand-side Abatement Rule projects.

In Victoria, provisions are in place to prevent double counting under the Emissions Reduction Fund, which replaced the carbon price that the Greenhouse Gas Reduction Scheme had set. The Emission Reduction Fund works as a reverse auction where those who create energy reductions from a variety of projects, including agriculture, vegetation, mining and gas, wastewater, energy efficiency, transport, and others, compete to earn the business of the government as the purchaser of these projects (Clean Energy Regulator, 2017). The government chooses projects based on the lowest cost reductions, and then provides incentives and funding for chosen projects. Where duplication in eligible activities occurs, stakeholders can choose to participate in either the scheme in Victoria or the Emission Reduction Fund, but not both (Jacobs, personal correspondence, January 7, 2018).

Despite these attempts to prevent double counting, creation of a white certificate program at the Australian national level has not occurred due to some concern about this double counting issue. Energy efficiency advocates think that a cap-and-trade system does not provide enough support for energy efficiency projects and federal adoption of programs similar to those that have emerged in New South Wales and Victoria (Nadel and others, 2017).

In 2006-2007, the EuroWhiteCert project attempted to address how white certificate markets should be set up in Europe. Issues of double counting under existing cap-and-trade schemes were addressed as researchers considered how energy efficiency lowers the overall demand for allowances. However, as mentioned previously, the role of white certificates in making it more cost effective for regulated entities to meet their caps has been something that European regulators have ignored since the E.U. ETS has not proven stringent enough to create an economic liability for regulated entities. This group also envisioned that energy efficiency could become a preferred resource in the merit order dispatch and be preferred over other forms of generation. Finally, the group considered the double counting of offset credits from Joint Implementation or Clean Development Mechanism credits from countries that may be integrated into the E.U. in the future. This concern has not yet become an issue, and given the low CDM and JI prices, will most likely also be ignored as a major form of double counting since the number of energy efficiency projects from these two mechanisms are modest (EuroWhiteCert, n.d.).

The group recommended that white certificate schemes remain separate from the E.U. ETS except if extra white certificates were created. In this case, they could be converted to allowances. A set aside of allowances from the ETS (as previously discussed occurs in RGGI for renewable energy) could be reserved for these types of retirements, and this set aside pool would help prevent the white certificates from having a dramatic impact on the EUA price. Stringent measures to ensure that the white certificates represent beyond business-as-usual upgrades with strict monitoring and verification on energy reductions was recommended (EuroWhiteCert, n.d.).

Additional

A white certificate would also not be considered “real” if it were issued for a project that would have occurred in a business-as-usual situation. This criterion of needing to be additional to what would have occurred in the absence of the white certificate program is called “additionality.” The logic here is that energy or emission reductions that would have occurred in the absence of the incentive should not be credited; otherwise, those white certificates would be bogus.

In Italy, the measures taken to generate a white certificate are considered additional if the technologies used in the project go beyond what would have been sold at the national level (Hamrin, Vine & Sharick, 2007). According to market regulators in Italy, additionality is the most challenging issue for evaluation of the project, especially in the industrial sector which comprises 64% of the projects. Moreover, it is difficult to tell whether an industry is installing the best technology available on the market for efficiency gains, or because it will save money and allow the company to be more competitive. Often these two go hand-in-hand. In order to prove additionality in the industrial sector, the technology installed must be 90% more efficient than the average efficiency of those on the market; this is a difficult standard when there are only a few boilers available for purchase. It is much easier to establish additionality in the residential market where there are minimum standards for appliances, and a project must exceed these standards to be additional. For both the industrial and civil sectors in Italy, if payback time is under 2-3 years, then the project is deemed to be financially viable without white certificates, and none are issued for these projects.

In order to calculate whether a project would have occurred in a business-as-usual situation, a few market effects need to be taken into account. These market effects include free ridership and the spillover effect, which will both be discussed in turn. Utilities who are trying to meet energy efficiency resource standards or defer the capital investment necessary for new capacity additions and serve their increasing load with existing generation facilities often offer their customers rebates for installation of energy-efficient equipment. For example, NV Energy offers small businesses rebates for installing particular energy efficient technologies through its Sure Bet Program. However, there will always be a portion of the population that would have installed the more efficient technology without the rebate, perhaps because the design of these technologies is more modern and preferable to the older version or because the customer wants to reduce his or her electricity bill. The people who would have installed the upgraded technology without the benefit of the rebate, but who took the rebate anyway are called free riders (Hamrin, Vine & Sharick, 2007). For any calculation of white certificates, some countries believe there should be a correction for free ridership; however, the size of this correction factor is up to debate (Bertoldi and others, 2005).

Spillover is a phenomenon that involves extra energy savings that were not subsidized by a rebate or incentive program. Participant spillover involves a customer purchasing additional energy-efficient devices because he or she received a similar product for free or at a reduced price and liked it so much that the customer decided to buy more energy-efficient devices (Vine, personal communication, December 4, 2017). This often occurs with LED light bulbs, which provide superior lighting and use 75% less energy (DOE, n.d.). Non-participant spillover is when someone purchases a specific energy-efficient technology because he or she sees or hears how well the technology has worked for a participant in a rebate or incentive program (Vine, personal communication, December 4, 2017). Some experts think that spillover and free riders cancel each other out, and for that reason some states and countries do not have a correction factor for either (Wirtshafter and others, 2012).

The correction factors for these market effects vary widely. In France, a 4% discount is applied to projects after their first year of operation to account for free riders and projects that do not last the nine years that is credited in year one of the project's life (Ministry of Ecological and Solidary Transition, 2016). The U.K. applies a 3.5% discount factor to these same projects. Insulation projects in the U.K. have a 12% discount factor applied to account for free ridership (Togeby and others, 2007). In New South Wales, free riders and spillover are accounted for in a 13% discount factor. New South Wales also is in the process of changing incentives for lighting upgrades based on evaluation studies that show customer adoption of LED lights in the absence of rebate programs (NSW Government, 2015). In Victoria, an embedded discount factor for free ridership is included in the calculation of credits given, and this factor differs based on technology (Jacobs, personal correspondence, January 7, 2018). These discount factors are not available to the public, but they are updated periodically based on technology prices; in November of 2017, the discount factor for compact fluorescent lights was changed (Environment, Land, Water and Planning, 2018). In Denmark, a 10-15% discount factor applies and is determined by the project. This factor accounts for free riders, spillover, and non-additional projects (Energi Styrelsen, 2013). For non-standardized calculations, which tend to be larger and more complex projects, the project proponent suggests the calculations and the project proponent must show explicitly what has been considered (Dyhr-Mikkelsen, personal correspondence, December 17, 2017). While Italy has no formal discount factor for free ridership, the architecture of the program is meant to prevent it. As an example, when an entity applies for 300 white certificates, often only 250 will be issued, and in this conservative issuance of white certificates exists an implicit correction for free ridership. While California does not have a white certificate trading program, to determine how much energy efficiency is additional to a business-as-usual situation, it discounts its energy efficiency programs by 30% to account for non-additional upgrades and free riders (Nemtzow & Siddiqui, 2008). Figure 9 below provides a quick comparison of discount factors in each country's program.

Figure 9: Comparison of Free Rider Discount Factors in White Certificate Programs

Location	Discount Factor
Connecticut	None
Denmark	10-15% (Energi Styrelsen, 2013)
France	4% (Ministry of Ecological and Solidary Transition, 2016)
Italy	None
New South Wales	13% (NSW Government, 2015)
United Kingdom	3.5% for most projects; 12% for insulation projects (Togeby and others, 2007)
Victoria	Embedded in calculation of VEECs and differs by technology (Jacobs, personal correspondence, January 7, 2018)
Denmark	10-15% (Energi Styrelsen, 2013)

Some energy experts claim that the rigorous standard of additionality should not be applied to either RECs or white certificates. Instead, the value of the REC or white certificate should simply serve to help bolster a technology that otherwise is not competitive with alternatives in the marketplace. Pinpointing an exact investment hurdle for energy efficient technologies can be very difficult. Alternatively, a list of approved technologies that are under-represented in the marketplace and need extra support to be adopted widely could serve as a guide for qualifying white certificates. This list of technologies could be modified as economies of scale were realized by the manufacturers, and the prices of some of these energy efficient technologies fell. A list such as this applies to white certificate projects that are implemented in France.[45] All projects that go above and beyond industry norms for a particular sector are considered additional and receive white certificates (Hamrin, Vine & Sharick, 2007). Similar sunset clauses on solar incentives have been placed in states like New Jersey where the state rebate declined from 70% per installed Watt in 2001 to 40% per installed Watt in 2006 (Tierney and others, 2011). RECs never had to meet an additionality test in the U.S., and some industry proponents question whether white certificates should have such a requirement (Martin, personal communication, November 8, 2017).

[45] This applies for all sectors except those related to energy efficiency, which have a higher benchmark. (Hamrin, Vine & Sharick, 2007).

Permanent

Unlike some offsets from the forestry sector that are supposed to last for 100 years, energy efficiency measures and their permanence are contingent on the type of technology that was installed. Instead of assuming that any energy reduction is permanent, a white certificate program should instead make some determination of how permanent a reduction is. Some white certificate programs recognize differences between technology types and lifetimes, while others apply a standard number of years to the project. Figure 10 summarizes how different programs apply dramatically different lifespans to the same two projects.

Figure 10: Comparison Lifetimes of White Certificates in Selected Countries

Country	Technology	Lifetime (years)
France	Freezer/Refrigerator Combo	10
	CFLs	7.5
United Kingdom	Freezer/Refrigerator Combo	12
	CFLs	16
Denmark	Freezer/Refrigerator Combo	10
	CFLs	8

From: Togeby and others, 2007[46]

It is important to note that the lifetime of the white certificate probably has a large bearing on its value since those that have a longer lifetime can then be used to fulfill compliance obligations for more years. In order to shed more light on how the determinations for the lifetime of these certificates was decided, a few key programs will be discussed.

Connecticut's program provides standard calculations in the Technical Reference Manual that estimate the project lifetime (and resulting Class III REC lifetime) based on the technology installed. The longest lifetime possible for these projects is 10 years, and the calculation considers early removals, building demolition, and savings deterioration over time (Holt, 2010).

Italy's program has always taken into account the type of technology in the calculation. In 2011, a *tau* factor was introduced into the calculation to boost the industrial sector. This *tau* factor weighted the white tags and increased them for a five-year period if the project had a long lifetime. The *tau* factor was 2.5, which helped boost national investments in energy efficiency projects. In 2017's Decree 11, the tau factor and multiplication factors for various technologies were eliminated, and now a three, five, seven, or ten-year lifetime applies.

In Australia, the two white certificate schemes have differing ways of determining a white certificate lifetime. In New South Wales, energy savings certificates do not have an expiration date, but do have a vintage based on when they were created, which is important for accounting and surrendering against obligations. Some projects are ex-post (created after the project had been implemented and monitored to create actual results). Other projects are

[46] In the original table published by Energy Analyses, Italy had a CFL lifetime of 5 years, but since 2011, these projects are ineligible for crediting. Also, freezer and refrigerator combos were listed as having a 5-year lifetime, but these projects have not been supported by Italian Scheme.

credited ex-ante (before the project has been implemented), and forecast savings are credited up-front for the lifetime of the project. This process is called “deeming” or forward creation, and some activities can be forward credited for a 25-year lifetime. In Victoria, projects are also given credits that will be generated over the lifetime of the project upfront in order to offset the purchase of the equipment. A conservative estimate (in the 40th percentile) of the lifetime of the equipment and the greenhouse gas savings is used to determine the number of Victoria Energy Efficiency Credits generated. If not used for compliance in the system before six years, credits will expire (Jacobs, personal correspondence, January 7, 2018).

In France, a similar system of deemed savings occurs, with a unique twist. Each kWh for certificates is labeled “cumac,” which is a contraction of accumulated savings and discounted. The energy saved over the lifetime of the project, which is defined as nine years, is credited in the first year. Assumed savings after the first year are discounted by 4%, presumably to account for equipment that fails or is taken out before its nine-year life has ended (Ministry of Ecological and Solidary Transition, 2016).

Under the Danish system, the lifetime of the project varies based on the type of technology, and in 2012, 6% had a lifetime of less than 4 years while 48% had a lifetime of over 15 years. The average lifetime of a project in Denmark is 10 years. The lifetime is determined through a weighted conversion. Savings in the first year are weighted by a factor that reflects the savings’ lifetime and the expected CO_2 savings. In the E.U. ETS conversion, whether or not a project falls under a capped sector is considered and corrected (Energi Styrelsen, 2013).

Verifiable and Enforceable

To assure that the emission reductions claimed are actually made, the project must have some way to calculate the white certificates generated, and for those projects that did not deliver, penalties must be enforced. Each white certificate scheme has its own way of measuring energy saved.

The typical forms of calculating the reductions involve measuring the before and after energy usage. Default energy usage rates for certain technologies are compared to what the technology being replaced, a calculation of the avoided emissions due to use of more efficient technologies, and some combination of the techniques, correcting for weather.

White certificate markets with active trading have the monitoring and verification techniques described in Figure 11.

Figure 11: Monitoring and Verification Techniques in Active White Certificate Markets

Location	Monitoring and Verification Techniques
Connecticut	Technical Reference Manual provides guidance for calculating savings and is updated periodically to improve accuracy as technologies, baselines, and savings change. Standard calculations for estimated savings are included in this manual. For utility Conservation and Load Management projects,

	certificates are discounted to account for free ridership and spillover. For projects undertaken without Conservation and Load Management funds, this discount factor does not apply but the measures must be endorsed by a licensed, independent third party (Holt, 2010).
Denmark	Energy savings are determined using one of the following methods: 1. standard values (typically used for residential projects), 2. specific calculation of the savings (used for larger, industrial projects), or 3. specific market impact through surveyed savings. (Energi Styrelsen, 2013). An audit of projects is undertaken every second year. A third party must do this check every four years. In addition to these audits, the Danish Energy Agency spot checks projects before projects expire (and before the new agreement is entered in to), which translates into every 3 years (Dyhr-Mikkelsen, personal correspondence, December 17, 2017).
France	Forecast energy savings are calculated based on standardized engineering estimates (Hamrin, Vine & Sharick, 2007).
Italy	Within the residential sector, since 2017 Decree 11 savings are monitored ex-post to determine certificates generated. Within the industrial sector, industries propose to the GSE market managers an algorithm to determine savings. If approved for the proposed savings generated AND the project is considered additional, then certificates are awarded.
New South Wales	Accredited Certificate Providers that have developed energy saving activities use independent third parties who audit and verify savings from each project. Set-aside deeds are used to withhold a percentage of certificates from the market from forward-created or deemed certificates until the third party audits and verifies that savings have occurred (IPART, 2016).
United Kingdom	Forecast energy savings are generated based on standardized engineering estimates. Monitoring only affects energy savings accredited in future schemes (Hamrin, Vine & Sharick, 2007).
Victoria	The savings are calculated after the project has been implemented and savings are based on how much energy was used compared to a baseline (Essential Services Commission, n.d.).

It is worth noting that some countries realize the limitations of the monitoring and verification of these projects. In Italy, it is fairly straightforward to monitor and verify projects in the industrial sector since these large energy users are acutely aware of their energy usage and monitor it closely. (Establishing additionality within this sector, however, is challenging, as previously discussed.) Within the civil sector, monitoring and verification is very complicated. Prior to the 2017 Decree, in 40% of civil sector applications, assumptions were made about energy savings for equipment retrofits based on known energy-usage amounts for the technologies that were swapped. However, in order to provide more accuracy to the program, now 100% of all civil sector projects are monitored ex-post for actual energy savings. This new form of monitoring and verification may be more accurate, but certainly is costlier for the Italian program. These high costs may be part of the reason why the market value of white certificates has soared over the last year from €100/toe to €350/toe (EPATEE, 2017).

A market effect that needs to be considered, and possibly corrected for during the monitoring and verification phase is the rebound effect. This phenomenon occurs when more efficient equipment is installed by a customer and then the usage of this equipment increases because it costs less to operate. For example, a customer with LED lights may be less fastidious about turning them off each night or while on vacation to deter burglars, knowing that they cost so much less to operate. This rebound effect causes more electricity to be used than would be expected by projections. Consequently, for monitoring and verification purposes, some type of real measurement of electricity use may be necessary to get an accurate picture of total reductions (Vivanco and others, 2016).

Ownership

After establishing the definition of the white certificate through evaluation of whether the certificate is real, additional, permanent, verifiable, and enforceable, one must trace the ownership of the certificate from its creation to the eventual selling to an entity for compliance purposes and retirement.

One of the greatest challenges of white certificates, especially from the residential sector, is the fact that they can be generated from an aggregate of projects. It may take several homes to generate one MWh of energy savings, and if the French unit of a TWh is used, then thousands of homes with retrofits would be necessary to generate this amount of energy savings. Aggregating these savings and tracking where they come from for purposes of accounting, is very challenging. This task becomes easier if projects are designed for situations like military base housing units where all houses are metered collectively. The public perception of a project such as this is also excellent as ratepayers can feel good about increasing the comfort of homes for military families (Barbour, personal communication, November 10, 2017).

Typically, if a project is completed with the benefit of rebates from the utility, then the utility retains the ownership of the white certificate. This reality can make it difficult to derive white certificates from the residential sector since most states with obligations for energy efficiency reductions have rebates for residential customers to reduce their energy usage through installation of more efficient equipment. In the U.S., within the industrial sector, many large energy consumers want to retain the white certificates they have created for their own energy reduction claims, which give positive public relations value, or to comply with current or future anticipated regulations (Hathaway, personal correspondence, December 18, 2017). Tracking these types of aggregated projects can also be cumbersome, as will be discussed in the next section.

In contrast to this situation, Italy has successfully implemented projects with ESCOs in both the civil sector, which comprises 32% of its market, and large industrial clients, which comprise the remainder of this market. Within the residential sector, citizens are eligible for a 65% tax credit for energy efficient upgrades. Prior to 2013, citizens could take advantage of this tax credit and create white certificates from these projects, but after Ministerial Decree 28/12/2012, it is not possible to receive both tax credits and white certificates from the same project.

In Denmark, the end user of the property or equipment is the owner of the energy savings. If the energy provider wants to claim the savings, then an appropriate amount of a subsidy for the energy retrofit must be given to the customer (The energy companies' energy savings effort, 2016).

In Connecticut, an unusual rule applies where if commercial and industrial projects have received no Conservation and Load Management (C&LM) funds for completion of a project, then the customer keeps 75% of the Class III RECs, while 25% go to the C&LM Fund. If the commercial and industrial customer does receive C&LM funds, then they are not eligible for any of the Class III RECs; most choose to receive these C&LM funds. For residential projects, customers can keep 100% of the RECs if no incentives or rebates from the C&LM Fund were used, but residential projects are not financially viable for Class III REC generation unless aggregated. If a customer uses some of a C&LM incentive, they can receive a pro-rated number of Class III RECs; however, payment for these RECs would be in the form of a bill credit to all customers since individual customer savings are not tracked. To this point, no customers have chosen this option, but have instead accepted the full incentives available from the C&LM Fund (Holt, 2010).

Tracking

Tracking of the white certificates goes hand-in-hand with the ownership. After the white certificate has been created, typically through an ESCO or a similar type of third party like Sterling Planet, they are sold to an entity that needs them for compliance purposes,[47] and then they are turned over to a regulatory authority like the Connecticut Department of Utility Control. Next, this regulatory authority catalogs the white certificates in a registry. Connecticut's registry is the New England Power Pool Generation Information System (NEPOOL GIS) where trades are publicly shown, but prices are not revealed.

Michigan uses the MIRECs platform where a description of the type of generation of the REC is described; however, the energy waste reduction credits are not visible because they have a short lifetime of one year. By converting the Energy-Waste Conservation Credits to RECs immediately, their lifetime is expanded to five years. Since the choice to extend the life of these credits is almost always selected, the MIRECs platform shows no Energy-Waste Conservation Credits. Consequently, the Energy Optimization Credits are tracked only internally for now, but an improved system to track these trades is envisioned for the future (Gould, personal correspondence, November 28, 2017).

[47] No major voluntary trades of white certificates have been made yet, but prospects for the voluntary market will be discussed in Section 3.

REC tracking systems can be regional or state-based. They cover the entire U.S.,but are a patchwork of different systems. In many cases, these REC tracking systems have been used in states with energy efficiency reduction targets to track trades. For each certificate generated, there is a distinct serial number issued, and a description of the type of generation (or in the case of white certificates, technology) is specified. For white certificates that involve an aggregation of many homes and different technologies, some type of generic descriptor may be used. And, if energy efficiency programs evolve to have carve outs for particular types of technologies or sectors served (such as low-income weatherization), then this would need to be noted in the description of this white certificate.

Conversion of this REC tracking system for acceptance of white certificates has occurred in Connecticut where Class III RECs are registered with the New England Power Pool Generation Information System (NEPOOL GIS), which has been modified to accept these "Conservation Certificates", as the GIS calls them. Once the certificates have been recorded on the NEPOOL GIS, they can be sold to regulated entities for compliance purposes (Holt, 2010).

Tracking of white certificates in Italy occurs through GME (Gestore dei Mercati Energetici SpA), the market manager in the country. In Victoria, tracking occurs through the Essential Services Commission where a registry is publicly available. In New South Wales, the government maintains a registry that lists the details of certificate providers, facilitates the registration and transfer of energy saving certificates, lists and tracks ownership of these certificates, and allows participants to surrender certificates to meet obligations or for voluntary purposes (IPART, 2015). In the UK, there is a spreadsheet of self-reported data from projects that is maintained by the Environment Agency, but the data in this spreadsheet are not verified (U.K. Environment Agency, 2016). The Danish Energy Agency does not have a national registry and just receives information about kWh reduced from branch organizations (Dyhr-Mikkelsen, personal correspondence, December 17, 2017).

This type of detailed tracking incurs additional transaction costs, which can lower the overall cost competitiveness of fulfilling compliance obligations through tradable white certificates. In the U.K., transaction costs for energy efficiency obligations were estimated to be around 10% of the lighting and 30% of insulation total investment costs (Mundaca, 2007).

Conclusion to Section II

The obstacles that white certificate markets face are significant, yet surmountable if applicable lessons learned from offset and REC markets are applied. The first challenge to these schemes is that nearly every jurisdiction where they exist defines them differently. Some schemes use units of electricity, which vary between kWh and TWh, while others use units of primary energy, such as tons of oil equivalent (toe). The U.K.'s system uses metric tons of CO_2 for these white certificates. Also, the technologies that qualify for white certificates vary by program.

The next challenge to these programs is that the certificates must be real, additional, permanent, verifiable, and enforceable to be considered valid. The "real" requirement is challenging when these programs co-exist with greenhouse gas legislation. In Italy, France, the U.K., and Denmark where the E.U. ETS exists, special care and consideration must be given to each project to make sure it is not counted in both the E.U. ETS and the white certificate program. Double counting exists in Italy and France, and as the E.U. ETS becomes more stringent, it will be interesting to see if regulators become more concerned with avoiding this issue. The challenge of the certificates being "additional" involves assuring that the white certificate program is not incentivizing projects that would have occurred in a business-as-usual situation. Many countries have a list of technologies that are underrepresented in the marketplace and use this list as qualification for projects. However, the list is somewhat subjective, constantly changes due to the economics of the technology, and is debated. This situation leads to some free riders in the system who would have implemented the technology without the benefit of the white certificate revenues. Spillover can also occur, which leads to a more widespread implementation of the technology than previously expected due to market participants or those they influence purchasing efficient technologies without white certificate revenues. And, there is the issue of the rebound effect, which refers to how some people use more energy once they have installed a technology that is cheaper to operate. These market effects make it difficult to estimate exactly how many of these white certificates are additional to a business-as-usual situation, and each market uses its own correction factor to account for these market effects. The permanence of these white certificates varies by technology, and the number of years credited to particular white certificates is dramatically different based on the program. Finally, each program ensures that the white certificates are verifiable and enforceable through monitoring and verification strategies that are specific to the location of the program. In some programs, multiple types of monitoring and verification protocols exist and consist of ex-post measurements of savings or ex-ante forecast savings.

Each white certificate must have an ownership trail and be tracked effectively. The ownership of a certificate can be complicated if the customer who implements the technology received a rebate from the electricity provider. In some markets, all or the subsidized portion of the technology is owned by the electric power producer if a rebate is used. Tracking systems are sometimes made public and operated by a governmental entity. In the U.S., the conversion of white certificates to RECs can make it difficult to monitor trades. The challenges that these white certificate programs face are noteworthy, and each market handles them differently, which makes future possibilities of trading among these various markets (in order to lower overall cost of compliance) seem far-fetched.

Section III: Future Market Potential in the U.S.

Although the challenges mentioned in the previous section are formidable, they are not insurmountable, as demonstrated by the successful white certificate schemes worldwide. Section 3 of this report will discuss the future potential for these white certificates in the United States through a discussion of national legislation, which could create a broad market for trading white certificates across state lines. This section examines a proposed EPA rule, developed by the Obama Administration, titled "Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units," published in October of 2015. The following section examines the Clean Power Plan's (CPP's) brief but complicated history in opening U.S. markets to energy efficiency trading mechanisms. An Emission Rate Credit (ERC), the CPP equivalent of a white certificate, has the potential to become a nation-wide trading mechanism with a central definition, verification, measurement, and tracking system. Unlike the state- and country-based systems described in previous discussions, this far-reaching tradeable instrument allows for state-based goals to be achieved through economies of scale.

Clean Power Plan

This section examines the CPP and its utilization of ERCs in depth, considering many of the same questions examined in the previous analyses. It delves into the complex considerations for assessing CO_2 reductions and the mechanisms states may use to achieve reduction targets. Then, comparing the CPP to drivers behind Renewable Portfolio Standards the authors re-examine the issue of additionality. Reviewing the work of the National Energy Efficiency Registry (NEER), the authors distinguish the importance of the foundation that has been created for CO_2 trading mechanisms in the U.S. and lessons learned from previous examples. Though the CPP has seen distinct opposition from the Trump administration, the future of emissions regulation in the U.S. remains undetermined. This section documents why changes in Administration are likely not end points for federal legislation regulating carbon emissions and how energy efficiency is an integral component.

The Environmental Protection Agency (EPA) was granted statutory authority to regulate GHG emissions under the Clean Air Act (CAA) Section 202(a)(1). This authority was clarified through the 2007 Supreme Court decision in the case of *Massachusetts v. EPA* and the associated 2009 endangerment finding. This finding was significant as it identified greenhouse gases in the atmosphere as an endangerment to public health and welfare, thus "trigger[ing] an affirmative statutory obligation" to regulate GHGs (Tsang, 2017). Decisions regarding the EPA's authority to regulate greenhouse gas emissions have continued to define the scope of regulatory power, inclusive of air pollutants from motor vehicles and stationary sources, like power plants as defined under CAA Section 111.

In August 2015, the EPA completed the CPP final rule to address CO_2 emissions in the electric power sector. Aside from lowering carbon emissions, the Plan's core objective was to protect the health and welfare of American citizens and limit the future impacts of climate change internationally (EPA, 2016). This Obama Administration rule requires states to submit plans to set emission limits from coal- and gas-fired plants, measured in pounds of CO_2/MWh of electricity generation (Ramseur & McCarthy, 2016; Sullivan, 2015a). Currently, stationary power plants produce 30% of all U.S. greenhouse gas emissions (Ramseur & Tsang, 2016). The intent of the CPP was to allow states to yield real CO_2 reductions from stationary sources by creating enforceable emission limits, targeted to their specific industries and local needs. The rule set interim targets for the period between 2022-2029, including a final target for each state to be met by 2030. The CPP utilizes the federal-state partnerships established through the CAA to coordinate best practices and technologies to achieve reductions through performance targets based on standards of performance for new stationary targets (Adams & Jordan, 2017; McCarthy and others, 2017; Tsang, 2017). The EPA expected the total CO_2 emission reduction in 2030 to be around 32% less than 2005 emission levels, though emissions in the power sector over the past decade have decreased significantly, owing to the plummeting price of natural gas and a stabilization in demand (McCarthy and others, 2017). The plan was intentionally flexible to allow compliance from a variety of mechanisms at the state-level, such as renewable portfolio standards, energy efficiency programs, emissions trading or cap-and-trade schemes, or any combination of these methods (Adams & Jordan, 2017).

Section 111(a) defines the standard of performance to "reflect the degree of emission limitation achievable through the application of the best system of emission reduction [BSER]" (Standards of performance for new stationary sources, 2017). However, these mechanisms did not provide avenues to create emission guidelines for existing power plants that had not been modified. Thus, the CPP intended to address this gap by establishing a CO_2 emission standard of performance incorporating BSER for existing power plants (Tsang, 2017).

Mechanisms for CO_2 Reduction

Similar to other sections of the Clean Air Act, the CPP delegates the determination of the best means to manage carbon pollution reductions, which fall on individual states. The EPA asserts that the plan is fair and flexible, providing strong but achievable standards to cut carbon emissions, which are driving global climate change (EPA, 2016; Tsang, 2017). The EPA evaluated each state's carbon emissions to provide a 2012 baseline and associated requirements. Because of the established baseline, early technology adopters would not receive credits for technology brought online before 2012. Supporters of the CPP lauded the rule as reasonable and feasible based on the cost and variety of mechanisms (McCarthy and others, 2017; NRDC, 2015).

The original proposal included four building blocks, which could be used by states to achieve the emission reductions within their individual plans. These component building blocks provide specific strategies to achieve the standard of performance posed by the EPA to meet emission rate targets through the most cost-effective mechanism (McCarthy and others, 2017).

- Building block 1: heat rate (fuel efficiency) improvements for coal-fired units, which vary regionally.

- Building block 2: generation shifts that produce less carbon pollution, primarily the displacement of coal units by natural gas combined cycle.
- Building block 3: projected annual increases in renewable energy generation, meaning electricity generation from zero-emitting power sources.
- Building block 4: eliminated in the final rule, required demand-side energy efficiency improvements in the commercial and residential sectors (Ramseur & McCarthy, 2016, Tsang & Wyatt, 2017; NRDC, 2015).

The influence of renewable energy on the overall reductions became more significant in the final rule, with the exclusion of block 4 (McCarthy and others, 2017). The flexibility of these mechanisms was estimated to reduce carbon pollution more cost effectively and at greater rates than if individual sites were only given the option of equipment and fuel changes. The activities suggested “beyond-the-source” or “outside the fence line,” such as generation shifts and demand-side reductions, would need to be applied by owners and operators. CPP critics have called this particular recommendation into question as outside the purview of the EPA and the Clean Air Act, as it stands (Tsang, 2017).

Ultimately, each state plan must accomplish the emission rate reductions through a combination of emission reductions at existing power generation sites and investment in new sources of generation with lower emissions. The EPA increased the flexibility of the mechanism at a national level by creating an ERC and emission allowance system that would allow heavy emitters to purchase credits or allowances at other locations in the power system while offsetting their own emissions. Much like a traditional cap-and-trade mechanism, these credits or allowances would inherently influence which plants run and at what frequency (NRDC, 2015). As the program progressed, the emission rates would be ratcheted down and the number of available allowances would decrease (Peskoe, 2015). These emission rate credits are a “tradable instrument with a unique serial number that ‘represents one MWh of actual energy generated or saved with zero associated CO_2 emissions’” (Peskoe, 2015; 40 C.F.R. §60.5790). Emission rate credits can be created by zero-emitting energy generation sources such as wind, solar, geothermal, hydro, wave, tidal, and nuclear plants but states may limit eligible sources based on their plans. Because the plans are determined by the state, some combined heat and power, biomass, or waste-to-energy projects may also be included, but only after accounting methods for each source have been accepted (Peskoe, 2015). Emission rate credits may also be generated via “gas-shift” or an increase in generation at a natural gas plant that would displace coal-fired generation, thus lowering the state’s overall emissions. In this way these ERCs serve as an instrument similar to a carbon offset for electric power producer, but they are distinct from an offset in that they allow energy efficiency to qualify and play a direct role in the market. These ERCs do this while avoiding double counting, which often occurs when white certificate schemes exist within cap-and-trade markets. The following section will explain how these ERCs could achieve these goals.

Mass- vs. Rate-based Plans

The federal implementation plan included two means to accomplish the final CPP rule: a rate-based or a mass-based trading program. The rate-based plan establishes a cap on the amount of CO_2 allowed per unit of energy produced, or emissions per megawatt hour. A mass-based plan sets an overall cap on the total CO_2 allowed, no matter how much energy is produced (Minnesota Pollution Control Agency, n.d; Sullivan, 2015a). Because the EPA cannot compel a state to compose its own plan, the CAA directs that if a satisfactory plan is not created for a state, the EPA can prescribe a plan (Ramseur & McCarthy, 2016). The CPP allows for the submission of multi-state plans if taking an emission standards' approach, which would allow a more regional application of the standards and a variety of other programs to achieve its target. If the state chose an emission rate target, the state would necessarily adopt an accounting approach based on each plant's reported CO_2 emissions (measured in pounds of CO_2 per MWh) (Ramseur & Tsang, 2016, NRDC, 2015). For rate-based plans, the EPA prepared emission performance rates for nearly every state based on a 2012 baseline and a 2030 target, mixing national performance goals and weighting them based on the mix of electricity generation within the state (McCarthy and others, 2017; NRDC, 2015). As mentioned above, the reductions allow a combination of direct changes to emissions from the existing generation portfolio, in combination with emission rate credits, to meet the proposed targets (EPA, 2016; NRDC, 2015).

There are several benefits of establishing rules at the national level to be implemented by individual states, though some similar programs already exist. First, a national policy establishes policy objectives and overarching standards for energy efficiency projects. Second, a top-down approach allows for a broad-scale analysis of which sectors, technologies, and accreditation standards are most efficient and effective. A critical component includes the cost benefits achieved through economies of scale. Finally, a national program encourages best practices and discourages the "race-to-the-bottom" issues often faced when states compete for business. A national plan considers all the working pieces, establishes caps across regions and industries, and leverages existing regulation bodies for measurement and verification, while providing similar opportunities for competitive ESCOs and companies to find low-cost solutions within the large marketplace. These non-government entities are likely to create the most beneficial system as verifiers because their ability to make money on the project is dependent on the resultant savings.

The mass-based system is simple in its approach, as it creates allowances for the total tons of CO_2 that will be allowed to be emitted in a year and does not generate any sort of tradable credit functioning primarily as a cap. These values would be based on EPA estimates and state verification. The state would then distribute the number of allowances to the power plants, setting a limit of metric tons of CO_2 allowed per year. At the end of the year, each plant would account for the tons emitted and then surrender the allowances for the total metric tons of CO_2 to the state regulator (Sullivan, 2015b). If any given plant reduced its emissions through efficiency or shifting to cleaner sources, it would be responsible for fewer allowances, lowering the cost of compliance. Mass-based systems have already been employed in California and under the Regional Greenhouse Gas Initiative (RGGI) program inclusive of Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont and are supported by both state and industry (NRDC, 2015). Like cap-and-trade mechanisms, once the cap is set and the allowances distributed, the tracking for this mechanism is relatively simple. Furthermore, the system is balanced because areas that can reduce emissions at the lowest cost will be compensated for offsetting the system through allowances, and older systems that cannot do so efficiently will run less or ultimately close (Sullivan, 2015a). These programs do not need a program to track efficiency because the reductions are found at each generation site (Sullivan, personal communication, December 1, 2017). This system would be adopted in states with limited resources because the burden of administration, measurement and compliance is much lower than the alternative mechanism. However, because this is the existing method for other rules, some may resist the alternative strictly to avoid the unknown. An impact of this method is the potential to constrict economic growth if the EPA estimates do not match actual growth over the course of the plan (Minnesota Pollution Control Agency, n.d.). A secondary consideration includes the idea of leakages from this scheme. States can build new fossil fuel plants under the existing EPA standards but the carbon emissions would not be included in the calculations of the original plan. This loophole threatens the central premise of the CPP, to reduce carbon emissions and reduce the impacts to climate change (Minnesota Pollution Control Agency, n.d.). Thus, adoption of a rate-based plan would be most beneficial in achieving the goals of the CPP.

Mass-based plans pose a few central concerns. Primarily, who decides which companies and generators receive the allowances, and how the allowances are balanced between carbon emitters and renewable energy developers? Next, this mechanism poses an inherent issue of equity—based on who pays and who earns income from these instruments. Policy makers and implementers need to balance the economic concerns for consumers and businesses, while at the same time coordinating across industries and types of energy. The easiest plan is not likely to address all the potential inequities or balance the potential benefits. Where CO_2 reduction mechanisms already exist (such as renewable energy incentives), there is concern that double counting may occur. The proposed CPP rule recognized the potential for these issues and requested feedback in their 2014 request for comment (EPA, 2014).

A state rate-based emission system determines how many pounds of CO_2 may be emitted per MWh of electricity from its power plants and includes the creation of white certificates to improve energy efficiency through the creation of these instruments and associated markets (Sullivan, 2015a). Therefore, each power plant must annually demonstrate that their emission rate was equal to or less than the rate-based limit (Sullivan, 2015a). Thus, the valuation depends on the emissions rather than the total amount of energy generated, allowing flexibility for growth over time. This system is more complex because it does not account for positive actions, like shifting to cleaner sources of electricity generation or energy efficiency. Thus, rate-based state plans would need to create a provision for emission rate credits (ERCs) to account for these additional emission savings. One ERC is one-megawatt hour (MWh) of emissions-free electricity generated; consequently, ERCs could be purchased to offset fossil-fuel energy production or other carbon emitting sources. Thus, when utilities offset carbon emissions through one of the methods, they have the opportunity to give or sell the credits to other companies (Minnesota Pollution Control Agency, n.d). Compliance is determined by the effective emission rate, which includes pounds of CO_2 divided by the megawatt hours of generation and the number of purchased ERCs (Sullivan, 2015a). Monitoring emissions and energy production at the power plants, as well as tracking and verifying energy efficiency projects will require new programs and staff in states with these plans. Because of the need for verification, the EPA or states would need to create programs for M&V accreditation. Energy Service Companies (ESCOs) with technical expertise would work with utilities to create these plans and increased participation with tech companies would provide a competitive advantage, generating results in the most effective and economic way (EuroWhiteCert Project, n.d.). Researchers have found states with pilot programs or early adoption are able to implement their schemes more rapidly and at a lower cost than those without any experience (Blackburn and others, 2017). The credits can be traded within states or regions, depending on the plan because the EPA recognizes the regional attributes of power, as long as the involved states all have rate-based plans. The regional approach provides a larger market to address carbon emission issues with the lowest cost approach (NRDC, 2015).

The integration of both rate- and mass-based plans across the states pose a complex problem for accounting, as some projects may cross borders. The intersection of states that focus on total emissions (mass-based states) versus those that look at emissions per unit of generation imposes the threat of double counting (Farnsworth, 2015). In order to avoid double counting of emission reductions, the EPA would have to track the direction of claimed reductions across states with shared borders and different plan adoption. When projects are developed in mass-based states to create ERCs, the credit could not be claimed by rate-based states, because the reduction would be counted twice. For example, in regions where caps already exist (like RGGI), the EPA may need to prohibit rate-based states from taking credit for renewable generation that is already accounted for under the caps. However, reversing the situation to where electricity is being generated in a rate-based state, mass-based states could develop projects to displace emissions and count them (Sullivan, 2015a). Any issues of double counting may be resolved through cooperative agreements between states and through an excellent tracking and verification system (Farnsworth, 2015).

The EPA asserts, existing tracking and verification systems for Renewable Energy Credits (RECs) could provide insight for tracking ERCs, though an independent verifier would be necessary to authenticate accounting of these credits (Peskoe, 2015). There is risk in creating these credits that real emission reductions will not occur because the cost of compliance is higher than in a cap-and-trade system (Sullivan, 2015b). Much like existing estimations in energy efficiency, the risk falls more on state regulators than industry and would be further complicated if state plans included emission reductions in commercial and residential sectors. Because ERCs represent one year of emissions, this requires a complicated system utilizing statistical sampling and applications based on the coverage area, which would account for the emission savings in one year (Sullivan, personal communication, December 1, 2017). Because the emission credits are similar to offsets, regulators will need to carefully account for these credits and similar programs (RECs) to determine if additionality exists and what projects count within these parallel plans. Several international programs assume future technology enhancements and economies of scale by wider adoption of these means will lead to successful implementation, along with creativity in application by utilities and industry (EuroWhiteCert Program, n.d.). The proposed market average baseline will help to prevent free ridership by power plants with naturally low emissions because the existing emission levels are well established. It will be essential to closely manage the plans throughout the process to effectively handle the measurement and verification of these systems over time, especially as emission levels are ratcheted down.

The Clean Energy Incentive Program (CEIP) is voluntary program intended to operate in tandem with the CPP and allow opportunities for CO_2 reductions before the CPP takes effect in 2022 (Ramseur & Tsang, 2016). This rule was published in the Federal Register in June of 2016, providing clarifications on design elements states could include in their plans to meet emission targets in energy efficiency, wind, or solar projects in low-income communities or renewable energy projects in participating states (Ramseur & Tsang, 2016). The program's voluntary "matching funds" for states to incentivize renewable energy installations and demand-side energy efficiency was intended to billow early adoption of these technologies that might not receive as much support from the building block strategy. Furthermore, the focus on low-income communities provided additional benefits in areas, which might not receive specific consideration in state plans (EPA, n.d.; McCarthy and others, 2017). In 2016, the House passed H.R. 5538 prohibiting the EPA from using appropriations to "finalize, implement, administer, or enforce" the proposed rule (Ramseur & Tsang, 2016). Furthermore, ongoing litigation on the CPP placed the CEIP and associated provisions within the EPA in questionable status to continue moving forward under its legal authority (Ramseur & Tsang, 2016). In 2017, under the Trump administration, the CEIP was withdrawn by the EPA along with the CPP 2015 final rule (McCarthy and others, 2017).

The National Energy Efficiency Registry

The National Energy Efficiency Registry (NEER) was developed with the intention of creating reporting and verification protocols from best practices internationally to track energy efficiency projects in the U.S. under the CPP (Kellen, 2015). Without a registry, it seemed energy efficiency emissions' savings would be difficult to track and verify (Stanton, personal communication, November 10, 2017). Similar tracking and verification methods exist for renewable energy projects with reporting standards and protocols, so NEER intended to create a mechanism to demonstrate compliance (Li & Stanton, 2016). Furthermore, NEER creators realized the potential to catalyze investment in energy efficiency by fashioning a market with clear rules and demonstrations of compliance to emission reductions (Li & Stanton, 2016). The promise of NEER was to find common approaches and terminology while aggregating data to prevent double counting of energy efficiency projects. The Registry would standardize evaluation measurement and verification, streamline reporting, and develop uniform methods of accounting for energy efficiency—all with the goal of keeping states and industry in compliance with the CPP (Kellen, 2015). Much like registries for Renewable Portfolio Standards

(RPS), NEER intended to reduce transaction costs for energy efficiency investments by the monetization of non-energy benefits (Li & Stanton, 2016).

The drivers of successful environmental markets are generally two-fold, a universally-accepted method of evaluation, measurement, and verification and a regulatory compliance program to enlist participants (NEER, 2017a). Leaning heavily on existing REC markets in the US, NEER went to work in 2015 developing compliance instruments in response to the CPP for energy efficiency. NEER recognized the need for specific definitions, clearly articulated standards, and an easily accessible web tool for tracking and selling the offsets from projects within states and regions. Like RECs, NEER anticipated the variance in project size and value, and focused more on quality control protocols, eligibility standards, and pathways to compliance. The registry was created with the goal of compliance and investments, providing a venue for accreditation of independent verifiers, as well as specific attributes of projects to buffer investors and owners. Per the language of the CPP, energy efficiency projects must demonstrate avoided MWh energy use based on gross or net savings. These savings would be tracked in the registry and can be reported annually or over multi-year periods depending on the provisions of the compliance instrument (Li & Stanton, 2016). NEER was created as a flexible mechanism to track many attributes of energy efficiency projects, even as public policy evolves over time (NEER, 2017a). Each asset and attribute could be tracked within the web-based system by its unique identification number. Not only would NEER contain energy efficiency project information and asset tracking, it is also intended to house archives of all the relevant project information regarding measurement and verification, quality assurance protocols and other significant documents held over the lifetime of the project and even after the instrument is retired. NEER has the potential to track assets individually or in groups, and contains descriptions of all attributes including credits, benefits, emissions reductions, offsets, and allowances (NEER, 2017a). One of the major goals of NEER is to allow for interoperability with existing tracking systems to both limit double counting and to reduce reporter burden (NEER, 2017a). The potential for selling and splicing units for sale in other markets is currently being explored.

Though NEER was convening for a short period, the group accomplished several important tasks, which could be restarted if the CPP or similar legislation is passed in the future. First, NEER created a system where a REC could be sold with all of its attributes, minus carbon. This was a key accomplishment as the EPA did not intend for RECs to be used as a means of compliance under the CPP. The spliced carbon portion could then be sold as an EPC, unless that piece was necessary to a state's REC compliance or as part of other programs, such as Green-e. NEER's procedural requirements were key to state plans created under the CPP but the registry also provided a measurement and verification system for energy efficiency projects outside of the new rule. The most basic NEER data verification tool collectively protected against double counting, however, under the CPP, states would need a third-party to verify their project and account for emission reduction because of the wide variety and applications of EE projects (Stanton, personal communication, November 10, 2017). The most recent accomplishment for NEER was the creation of state-based energy efficiency roadmaps. The document presents the scope of energy efficiency initiatives and opportunities for state compliance using the registry to track and enable trading of energy savings from utilities, commercial spaces, and other sources of emissions within each state (NEER, 2017b).

Renewable Portfolio Standards and Emission Rate Credits

Renewable Portfolio Standards (RPS) have been adopted by 29 states and the District of Columbia. This variable set of standards define requirements for a specified percentage of renewable electricity to be generated by investor-owned utilities, municipalities, and electric cooperatives within each state, including total generation targets and associated dates (Durkay, 2017). Most systems require tracking of compliance and a tradable credit (Browne, 2017). There have been significant concerns that the existing policies would make it more difficult to incentivize additional reductions in emissions or remaining low-cost options for renewable energy generation. This apprehension has moved states to action, planning ahead to make sure existing programs will be CPP-compliant. The unfortunate reality for these early adopters is their emission reductions and added zero-emissions capacity from the past decade of RPS adoption cannot be counted in their CPP goals moving forward. However, additional renewable deployment and energy efficiency projects can be utilized in cases where options are limited. If regional markets develop, the RPS-compliant states may have ERCs to trade within the market, and pilot projects accomplished early may help these programs to be achieved at a much lower cost than in other locations. The CPP specifies ERCs were intended to be separate from RECs, but an entity could produce both types of credits where eligibility overlaps (Browne, 2017). Other states have voluntary renewable energy goals, but these will not impact ERCs in the same way. In short, rules and best practices will need to be established if ERCs are part of any compliance rules at a national level.

Current Status of Clean Power Plan

The Clean Power Plan was the first set of national emission standards to address carbon pollution from power plants (EPA, 2016). Litigation challenging the Clean Power Plan began before the final rule was published in the *Federal Register*. When the rule was proposed in 2014, a number of states throughout the country and Murray Energy Corporation argued that the EPA’s proposal to regulate carbon emissions exceeded their legal authority (Tsang & Wyatt, 2017). The challenge in the D.C. Circuit Court of Appeals was rejected because the court did not have the “authority to review proposed agency rules” and encouraged petitioners to wait until the final rule was published (Eagan, 2015; Tsang & Wyatt, 2017). Precedent and the language of the Clean Air Act both suggest the primary responsibility for air pollution control falls on state and local governments (Wall Street Journal Editorial Board, 2017). Following the publication of the final rule and the filing of additional litigation against the EPA, the U.S. Supreme Court voted to stay implementation of the rule. The EPA filed a motion requesting a temporary abeyance on the existing litigation against the CPP (more than a dozen consolidated cases), likely in an effort for the administration and the EPA replace or rescind the rule (Anderson, 2017).

A proposed repeal by the Trump administration on October 10, 2017 touted the CPP as, "a burden to the development or use of domestically produced energy resources" (McCarthy and others, 2017; Government Publishing Office, 2017). The repeal followed the Trump administration's Executive Order 13783, "Promoting Energy Independence and Economic Growth"—which required heads of federal agencies to review existing regulations and policies (agency actions) that potentially burden "the development or use" of domestically produced oil, natural gas, coal, and nuclear energy (FERC, 2017). The proposal to rescind the CPP required a 60-day public comment period, which was later extended to January 16, 2018 following an announcement of a public hearing on the issue (Ufner & Igleheart, 2017).

Twelve U.S. states and some municipalities have requested that the EPA Administrator recuse himself from participating in the agency's repeal because of his long-standing opposition (Carbon Pulse Daily, January 9, 2018). In the case *Pruitt v. McCarthy* (2015), Scott Pruitt sued the U.S. EPA on behalf of the Oklahoma Department of Environmental Quality, asserting the Clean Air Act (in the form of a proposed rule), was outside the authority given the EPA to manage the emissions of coal-fired power plants (Eagan, 2015). Additionally, Oklahoma joined plaintiffs following the publication of the final rule.[48]

The Trump administration is pursuing a method of regulating carbon emissions within the 'fence lines' of the EPA's authority. According to the article, the EPA is expected to propose a rule in the coming year. This is a major step, as it indicates the intention to replace rather than wholly repeal the original regulations. The action indicates an acknowledgement from the administration of the 2009 endangerment finding and a need to address the implications of the scientific underpinnings (Axios, 2017). The EPA recently proposed an extension of the comment period for the repeal of the Clean Power Plan until April 26, 2018 in response to "significant interest surrounding [the proposed action]" (Walton, 2018).

Interestingly, many utilities and power producers have reported their investment strategies will comply with the CPP because emission reductions targets are currently accomplished by increased adoption of renewable generation and market projections and technological innovations lean towards this and expanded measures for energy efficiency. NEER has proposed a range of energy efficiency projects ranging from replacement of facility equipment, add-on apparatus, and operational improvements. The baseline and start dates of these projects vary and can be changed early on or upon equipment failures (NEER, 2017a). Similar to existing policies, NEER promotes early adoption for existing systems as well as standards for new construction, renovation, and overall energy efficiency improvements. Aside from building new markets for energy efficiency projects through emission reduction credits in the CPP, NEER and other CPP proponents expect the provision of information, clear articulation about successful projects, and operations and maintenance training to play a major role in the success of these EE projects. It is common knowledge among utilities that savings from energy efficiency cost a fraction of the price of new generation, regardless of the source. The recent

[48] West Virginia et al v. EPA, no. 15-1363 (D.C. Circuit docketed October 23, 2015).

advances in solar technologies have significantly lowered the cost for acquisition and installations, pointedly increasing penetration to the energy market (Adams & Jordan, 2017). The most notable consequence of these changes is the implications on investment in the power industry. It is very difficult to make major infrastructure investments when there is a lot of regulatory uncertainty. In view of this fact, the EPA is still accountable to the public with regards to the endangerment finding, and it will continue to be compelled to action pertaining to greenhouse gases and public health. Thus, the absence of the CPP does not mean no action will be taken, especially considering the voluntary action of existing industry leaders and more stringent state regulations as seen during the past decade (Adams & Jordan, 2017).

Looking Toward the Future

The Clean Power Plan took years to develop as a long-term action plan to target CO_2 emissions with a singular domestic policy, addressing the concerns of the 2009 “endangerment finding” regarding greenhouse gases. Though the future of the Clean Power Plan is uncertain, the EPA will still need to protect the health and welfare of citizens as exposed in the initial finding, in one way or another. The obligation still stands to reduce CO_2 emissions from power plants across the U.S. through some policy or rulemaking mechanism (McCarthy and others, 2017). One critical issue the team will face is the distinct division between states on their support for the existing mechanism. In April 2017, 17 U.S. states filed a legal challenge in support of the CPP against the Trump administration’s efforts to stifle the regulation of emissions (Valdmanis, 2017). On the other hand, 12 states previously brought litigation against the EPA for overstepping its regulatory authority.

Initial scoping began for the CPP in early 2012 and the effort to create, propose, and receive responses from the public on the plan has been momentous. The Stationary Source Regulation program has seen major increases in the operating budget since the Clean Power Plan rulemaking began, with almost a 50% increase in the budget from $25 million (FY 2015) to $37.5 million (FY 2016) based on the complexity of power plant rulemaking, response, and review of state plans (EPA, 2015a). The staffing and legal expertise needed to wade through over 4.3 million comments during the process and the following litigation easily justified the expense, but the cost of implementation warrants additions to the budget for regulation and review at the federal and state levels (EPA, 2015b).

It is the expense and expansive reach of this policy area that brings pause when reflecting on the current situation. Researchers have questioned the viability of utilizing the tools and mechanisms of the CPP in its existing state, or if the policy will be repealed altogether. Because of the extensive input from stakeholders, states, and the public it seems almost wasteful to scrap the CPP altogether, though as previously mentioned there are some questions on portions of the plan, which may stretch outside the scope of EPA’s regulatory authority. It makes sense, if these allegations are true, to revise portions of the plan; however, starting over may not be the most efficient or effective mechanism.

The exact sections of the CPP to carry forward would likely be a point of discussion for different stakeholders, but there are a few key components worth retaining as they could inform future regulatory development. For the purpose of this paper, ERCs remain a central focus for rate-based plans. This proposed trading mechanism would support zero-emission generation sources and energy reductions and could be utilized in future policy since it allows these technologies to play a role in and benefit directly from the market.

Trading mechanisms in other policy areas, such as RECs have demonstrated the viability of this sort of structure and returned with lessons learned in regard to evaluation, measurement, and verification, instrument attributes, and the role of third party qualification and verification task management. NEER's work revealed the benefits of independent verifiers and qualified reporting entities to providing oversight in these programs, which would not depend wholly on the capacity of a government entity to manage. Additionally, many verification groups are able to oversee the costs of energy efficiency and renewable energy projects for investors at a manageable rate, which also benefits their operations (NEER, 2017a).

Though the future of the CPP is currently undecided, the need for reductions in carbon emissions by the EPA are immanent. The CPP provides a number of mechanisms to approach the issue and the instruments could be combined in a variety of ways to accomplish the goal. Assuming the current administration will see the efficacy of modifying rather than repealing the existing CPP, some or all of these instruments may reappear in the future. Keeping the ERCs would have major implications for energy efficiency as it would allow it to benefit directly from the market.

Other Demand for White Certificates

Beyond the demand for white certificates through a revival of the tradable ERCs in the CPP, there is the possibility that state energy efficiency legislation in the twenty-nine U.S. states that have these requirements could change to adopt or enhance existing trading. An estimate of future market potential based on existing energy efficiency regulation was completed by the National Renewable Energy Laboratory in 2009. An update of this estimate is necessary given how these regulations have changed, and most have become more stringent since 2009. However, given the huge legislative changes that would be necessary for trading to be adopted into all of these energy efficiency standards, this estimate is not a realistic prediction of future market potential.

Alternatively, a national Energy Efficiency Resource Standard that allows for trading could emerge. In 2009, the prospects for this EERS were greater when Representative Ed Markey introduced the "Save American Energy Act" to Congress. Given the states' experience with trading and low volumes of white certificates traded, this is not likely to happen. Also, these types of programs would require demonstration of significant economic benefits, outweighing the administrative burden of tracking and tracing trades.

Another possible market for tradable white certificates exists within the new Renewable Energy 100 (RE100) group of companies, who have pledged to source 100% of their energy from renewable sources by a target date in the future. Huge energy consumers like Facebook, Google, Bank of America, and Ikea have signed onto this pledge, and entire teams of people within these companies are tackling this challenge (RE100, n.d.). Given that it is more cost effective to reduce energy emissions rather than source new electricity, it would behoove these RE100 companies to first consider what energy savings they have at their disposal. A voluntary market within this group could be formed, and by trading certificates, they could reduce their overall loads and the amount of renewable energy that they would need to source. However, the same issues that have plagued the voluntary white certificate market (described in detail in Section 1) may prevent these RE100 companies from adopting an internal voluntary trading system.

No robust voluntary trading exists at this point worldwide. NYSERDA attempted a pilot program around 2008 where energy saving certificates were aggregated from qualifying projects and then sold in an auction to consumers and brokers, but this program was abandoned shortly after it started (Friedman, Bird, & Barbose, 2009). Victoria's program allows for voluntary surrender of certificates by obligated entities, and do so to meet public pledges they have made (Jacobs, personal correspondence, December 7, 2017). Otherwise, voluntary markets for white certificates are absent from the countries with these schemes.

Conclusion to Section III

The future potential for white certificate markets in the U.S. seems largely contingent on the inclusion of energy-saving credits in future federal greenhouse gas legislation, rather than in state-level white certificate trading programs. Existing Energy Efficiency Portfolio Standards and Renewable Portfolio Standards have limited provisions for trading of white certificates, and to this point no robust market has developed in the U.S. The CPP, however, had a significant role for ERCs that would have allowed energy efficiency to play a direct role in the federal greenhouse gas market as regulated entities bound by rate-based standards could use ERCs to help them reduce their overall emission portfolio. Some resurrected version of the CPP could emerge that would allow for energy efficiency to benefit directly from a greenhouse gas market, without concerns over double counting, which occurs in many markets that have both a cap-and-trade system and a white certificate program.

Other possible markets for white certificates may exist in the voluntary realm as RE100 participants could form an internal market for reductions before they attempt to source 100% of their electricity from renewable sources. This type of voluntary market could improve the perception of voluntary customers, and white certificate markets like those that exist for renewable energy certificates could possibly form. However, the prospect of the development of these voluntary markets is far less likely than the rise of energy-saving certificates through some type of rate-based federal greenhouse gas legislation.

Conclusion

In the U.S., the white certificate trading programs that have been created in Connecticut, Nevada, and Pennsylvania have not had the success of programs abroad. The primary reason for low volumes of white certificates traded in these states, namely Connecticut where trades have occurred and can be tracked, is due to the energy efficiency reduction targets not being stringent enough to incite trading. In Connecticut, other incentives for energy efficiency through RGGI auction proceeds and valuation of energy efficiency within the NEPOOL forward capacity market trump the value and administrative burden of developing Class III RECs. These incentives have also driven these Class III RECs to trade at the price floor.

Lessons from other countries and their experience with these programs can be helpful as the U.S. looks toward some type of tradable white certificate or ERC in future iterations of a Clean Power Plan. A retrospective study from the U.K. speculated on why there were low levels of trading; the study highlighted that in many cases it was more economical to make in-house reductions than to trade, and there was a positive public relations value to making reductions onsite. This paper also showed that some trading may not be occurring because white certificates are being banked for future use, some companies wanted to make reductions to gain valuable experience with these tradable certificates, and companies found there were few financial gains to be made by trading because of low market liquidity (Mundaca, 2007).

Italy made their program a success by requiring that 60% of energy reductions be made through trading white certificates; providing a guaranteed market for this instrument. Also, Italy, France, New South Wales, and Australia began their white certificate trading programs with relatively “soft” or easy targets to meet. While initially criticized for these less-than-stringent requirements, starting the market in this way allowed market participants to gain familiarity with the system’s rules and accounting and to budget for change over time (Vine, personal communication, December 4, 2017). While it may make sense to eventually allow for banking of certificates into future compliance periods and for borrowing of certificates from future compliance periods in order to promote more white certificate price stability, perhaps banking and borrowing should be introduced after the first trial or experimental phase of a program such as this. The experience with the E.U. ETS Phase I (when the allowance price dropped from €27 to €.1 between May of 2006 and May of 2007) demonstrated the market was oversupplied with allowances and baselines were set too high. This example shows the dangers of allowing the mistakes of one compliance period overflow to the next and the importance of gathering accurate emissions data for baselines (Chevallier, 2010).

A decision about whether the market should have a price floor and ceiling is important to consider. Both a floor and ceiling can buffer volatile markets, but also distort a free market, with the floor standing in the way of allowing reductions to be made at the lowest cost the market can bear and a ceiling preventing trading from going higher due to a high cost of reduction and few opportunities for reductions. These price assurances, however, can help both fledgling technologies and companies struggling to handle the cost of compliance. A floor helps provide market assurance that by installation of a particular technology, a minimum return on investment will be made. A price ceiling can help companies budget for the maximum cost of complying with a white certificate program. Strategic reserves of white certificates could also be used to buffer prices (Wood & Jotzo, 2009).

When designing a program for white certificate trading, one should be careful that it does not overlap with existing or planned greenhouse gas regulation. The current programs in Denmark, France, and Italy have some overlap with the E.U. ETS, and while this may seem inconsequential given the low allowance price within the ETS, this type of overlap will create challenges later as the cap is ratcheted down, and the value of both white certificates and the EUA is consequential and provides two significant incentives for the same reduction. Furthermore, accounting of reductions and maintaining a firm cap is challenging when reductions are double counted.

This direct double counting is not yet an issue in Connecticut where the RGGI market only covers power generators with a capacity of 25 MW and greater and Tier II RECs created from industrial facilities are simultaneously trying to meet a greenhouse gas cap and generate RECs. Under the proposed Clean Power Plan, double counting would not occur because of the rate-based system where emission rate credits from emission-free sources of generation and energy efficiency can be sold to companies that cannot meet their emission targets. This direct participation in the market prevents energy efficiency from being double counted.

Who is responsible for the reductions differs by program and is contingent on whether the market is regulated or deregulated. In the U.K., large energy users trade certificates. In all other programs, either the energy suppliers or retailers are responsible for making reductions. In places like Nevada, the U.K., and France where the energy supplier is responsible for making the reductions, there is an implicit conflict of interest since the energy supplier earns revenues from electricity sold. Decoupling sales from profits allows for electricity providers to recover their costs and earn a pre-determined profit, thereby avoiding the drive of electricity providers to sell a kWh to consumers; however, these programs are not ubiquitous and are implemented in just 25 U.S. states (Alliance to Save Energy, 2013). In Italy where the distributors (instead of the generators) have the obligation to meet energy reduction targets, there is less of a push to sell kWhs and more of a focus on energy service for customers (Bertoldi, 2011).

The units chosen for the white certificate become important if international trading (as currently occurs within the E.U. ETS and separately among Ontario, Quebec, and California) is envisioned in the future (Environmental Defense Fund, 2017). Broadening the market borders makes sense if making the cheapest reductions is the goal of the program; however, alternative social benefits such as better lighting and more comfortable homes from these reductions would not always be experienced by the population that purchases them. With regards to the units chosen for a white certificate, it is important to clarify whether they are in terms of primary energy (as in Italy), electricity (as in the U.S., Denmark, and France), or carbon (as they are in the U.K. and Victoria). If a unit of energy is chosen, then the goal of the white certificate policy is most likely energy reductions instead of carbon dioxide reductions. The carbon intensity of each grid varies widely, and if the units are in terms of energy, then white certificates in clean grids like Iceland (with 100% renewable energy - Askja Energy Partners, n.d.) would have a radically different carbon equivalent than those from coal-reliant countries like China (with coal comprising 73% of their energy - S&P Global Platts, 2014). Ultimately, the conversion of white certificates to carbon equivalence could shift project development from clean grids to those with a heavier reliance on coal since more credits would be earned from displaced electricity in carbon-intensive electrical grids.

Standardization of what qualifies for a white certificate will allow for widespread fungibility. The current credit multipliers applied to the energy efficiency credits from peak power production and RECs from residential solar projects has made other states reluctant to trade RECs with Nevada. Similar problems would occur if a universal definition of a white certificates was not created. Clarity on which technologies are eligible, the lifetime of the white certificate for each type of technology, consistency on updates to eligible technologies, and whether or not white certificates are created through only electricity reductions or both electricity and natural gas reductions (as is allowed in New South Wales and Sterling Planet's White Tag®) is necessary.

The CPPs' ERCs in the rate-based plan would allow zero-emission, energy-generation technologies and energy efficiency to play a role in and benefit directly from the market. This participation in the market could allow for the phasing out of complimentary policies like EERSs, RPSs, white certificate trading programs, and utility rebate programs. Simplifying incentives for renewables and energy efficiency could avoid double counting across programs and reduce the administrative burden of tracking and verifying different instruments. Although the Trump Administration is attempting to repeal the CPP, some iteration of it is likely to be resurrected given the enormous amount of money, time, and thought that went into its creation and the millions of comments the proposed rule elicited. The U.S.'s adoption of this rate-based plan could serve as a model for other countries like Italy who are struggling with how to have a white certificate market that co-exists with a cap-and-trade system without double counting emission reductions. Consideration of this rate-based plan could be key for Ireland, the Netherlands, Portugal, Romania and Bulgaria, who are interested in white certificates as a policy instrument (Bertoldi, 2011).

If the U.S. did adopt some form of ERC or white certificate in national legislation, there is the possibility that a voluntary market could form. Or, voluntary pledges of companies through the RE100 initiative could provide a driver for a voluntary market, but the product remains confusing for voluntary customers to understand, and given experience around the world, voluntary markets are not thriving.

Experience to date with white certificate trading has created a diverse portfolio of program approaches as each state and country has forged its own way in this emerging type of market. Careful consideration of the benefits and pitfalls of each selected approach, and the revisions made to these approaches over time, should help policy makers design a more elegant way to incentivize energy reductions in future iterations of greenhouse gas legislation, energy allowance trading, or stand-alone white certificate programs.

Interviewees (in alphabetical order by last name)

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References

Adams, A. & Jordan, R. (2017, October 12). Stanford experts discuss the effects of rolling back the Clean Power Plan. Stanford News. Retrieved December 22, 2017 from https://news.stanford.edu/2017/10/12/effects-rolling-back-clean-power-plan/.

Alliance to Save Energy. (2013, October 24). Utility rate decoupling. Retrieved January 11, 2018 from http://www.ase.org/resources/utility-rate-decoupling-0.

American Council for an Energy-Efficient Economy (ACEEE). (2014). Molina, the best value for America's energy dollar: A national review of the cost of utility energy programs. Washington, DC: ACEEE. Retrieved December 19, 2017 from http://aceee.org/research-report/u1402.

Anderson, J. (2017, August 11). Court issues indefinite hold in 111 (b) litigation. American Public Power Association. Retrieved January 10, 2018 from https://www.publicpower.org/periodical/article/court-issues-indefinite-hold-111b-litigation.

Askja Energy Partners. (n.d.). Energy data. Retrieved January 11, 2018 from https://askjaenergy.com/iceland-introduction/energy-data/.

Axios. (2017, December 18). Trump's EPA takes first step toward new carbon rules. Retrieved January 10, 2018 from https://www.axios.com/trumps-epa-takes-first-step-toward-new-carbon-rules-1515110661-90ee97a4-82bc-405b-b9bc-8e7cbf37482f.html.

Barbour, W. (2017, November 10). Personal communication. (E. Aldrich, interviewer).

Barrett, J. (2018, January 9). Personal communication via email with E. Aldrich.

Berkshire Hathaway Energy. (2017). Lighting up the Nevada Economy. Retrieved December 20, 2017 from https://www.berkshirehathawayenergyco.com/our-businesses/nv-energy.

Bertoldi, P., Rezessy, S. & Ürge-Vorsatz, D. (2005). Tradable certificates for energy savings: opportunities, challenges, and prospects for integration with other market instruments in the energy sector. *Energy & Environment 16*(6): p. 959-992. http://journals.sagepub.com/doi/pdf/10.1260/095830505775221498.

Bertoldi, P. of the European Commission, JRC. (2011, December). Assessment and experience of White Certificate Schemes in the European Union. Retrieved December 20, 2017 from https://www.iea.org/media/workshops/2011/aupedee/Paolo_Bertoldi.pdf.

Bertoldi, P. (2017, November 27). Personal communication. (E. Aldrich, interviewer).

Blackburn, C.J., Flowers, M., Matisoff, D., Moreno-Cruz, J. (2017). Do Pilot Programs Alter Non-Participant Behavior: Evidence from a Green Building Standard. Paper presented at the meeting of the Association for Public Policy Analysis and Management, 39th Annual Fall Research Conference.

Brander, M., Sood, A., Wylie, C., Haughton, A., & Lovell, J. (2011, August). Electricity-specific emission factors for grid electricity. Technical Paper. Ecometrica. Retrieved February 22, 2018 from https://ecometrica.com/assets/Electricity-specific-emission-factors-for-grid-electricity.pdf.

Browne, A. (2017 Spring). RPS Evolving: States take on U.S. climate goals. American Bar Association: Natural Resources and Environment. *Science & The Law*, 31(4). Retrieved January 25, 2018 from https://www.srectrade.com/blog/srec-markets/rps-evolving-states-take-on-u-s-climate-goals.

Carbon Pulse Daily. (2018, January 9). Bite-sized updates from around the world: Recuse yourself. Retrieved January 10, 2018 from http://carbon-pulse.com/45492/.

Center for Resource Solutions Report. Retrieved December 20, 2017 from https://resource-solutions.org/wp-content/uploads/2015/08/Insights-into-the-Renewable-Energy-Market.pdf.

Center for Resource Solutions. (2017, July 7). Green-e framework for renewable energy certification. Version 1.0. Retrieved January 26, 2018 from https://www.green-e.org/docs/energy/Green-e%20Framework%20for%20Renewable%20Energy%20Certification.pdf.

Chevallier, J. (2010, February 22). The European carbon market (2005-2007): banking, pricing, and risk-hedging strategies. Retrieved December 20, 2017 from https://hal.archives-ouvertes.fr/halshs-00458787/document.

Clean Energy Regulator. Australian Government. (2017, November 9). Emissions Reduction Fund: How does it work? Retrieved February 26, 2018 from http://www.cleanenergyregulator.gov.au/ERF/About-the-Emissions-Reduction-Fund/How-does-it-work.

Connecticut Department of Energy and Environmental Protection. (2013, April 26). Restructuring Connecticut's Renewable Portfolio Standard. Retrieved December 20, 2017 from http://www.ct.gov/deep/lib/deep/energy/rps/rps_final.pdf.

Connecticut Department of Energy and Environmental Protection. (2014, April). Regional Greenhouse Gas Initiative (RGGI). Retrieved December 20, 2017 from http://www.ct.gov/deep/cwp/view.asp?a=2684&q=332278&depNav_GID=1619.

Cook, O. & Karelas, A. (2009, September) Insights into the renewable energy market: A brief overview of procurement trends, drivers, and impacts of voluntary commercial purchasers.

Database of State Incentives for Renewables & Efficiency (DSIRE). (2016, January 20). Energy Portfolio Standard: Program overview for Nevada. Retrieved December 20, 2017 from http://programs.dsireusa.org/system/program/detail/373.

Database of State Incentives for Renewables & Efficiency (DSIRE). (2017a, May 16). Renewable Energy Standard: Program overview for Michigan. Retrieved December 20, 2017 from http://programs.dsireusa.org/system/program/detail/3094.

Database of State Incentives for Renewables & Efficiency (DSIRE). (2017b, November 2). Renewables Portfolio Standard: Program overview for Connecticut. Retrieved December 20, 2017 from http://programs.dsireusa.org/system/program/detail/195.

Database of State Incentives for Renewables & Efficiency (DSIRE). (2018, January 8). Alternative Energy Portfolio Standard: Program overview for Pennsylvania. Retrieved January 11, 2018 from http://programs.dsireusa.org/system/program/detail/262.

Demand Manager. (2017, December 15). Certificate Prices. Retrieved December 20, 2017 from http://www.demandmanager.com.au/certificate-prices/.

Department of the Environment and Energy. Australian Government. (n.d.). Emissions Reduction Fund. Retrieved January 20, 2018 from http://www.environment.gov.au/climate-change/government/emissions-reduction-fund.

Department of Industry, Innovation and Science, Australian Government. Office of the Chief Economist. (2016). Australian Energy Update 2016. Retrieved February 12, 2018 from https://www.industry.gov.au/Office-of-the-Chief-Economist/Publications/Documents/aes/2016-australian-energy-statistics.pdf.

Durkay, J. (2017, August 1). State Renewable Portfolio Standards and Goals. National Conference of State Legislatures. Retrieved January 25, 2018 from http://www.ncsl.org/research/energy/renewable-portfolio-standards.aspx.

Dyhr-Mikkelsen, K. (2017, December 21). Personal communication via email with E. Aldrich.

Eagan, C.V. (2015, July 17). Oklahoma ex rel. Pruitt v. McCarthy. Opinion and Order in Case No. 15-CV-0369-CVE-FHM (N.D. Okla. Jul. 17, 2015). Retrieved January 10, 2018 from https://casetext.com/case/oklahoma-ex-rel-pruitt-v-mccarthy.

Emmy: Registre National des Certificats d'Economie d'Energie. (2018). Cotation du kWh cumac. Retrieved March 24, 2018 from https://www.emmy.fr/public/donnees-mensuelles?precarite=false.

Energi Styrelsen. (2013, November 27). Implementation of the Energy Efficiency Directive: Communication to the Commission on methods for operating energy efficiency obligation schemes. File no: 2532/1650-0001. Retrieved December 20, 2017 from https://ec.europa.eu/energy/sites/ener/files/documents/article7_en_denmark.pdf.

Environment, Land, Water and Planning. (2018). Victorian Energy Upgrades. Victoria State Government. Retrieved January 20, 2018 from https://www.energy.vic.gov.au/energy-efficiency/victorian-energy-upgrades.

Environmental Defense Fund. (2017, September 22). Western Climate Initiative expands: Ontario to join California-Quebec carbon market. Retrieved January 11, 2018 from http://blogs.edf.org/climatetalks/2017/09/22/western-climate-initiative-expands-ontario-to-join-california-quebec-carbon-market/.

Essential Services Commission. (n.d.). Certificates (VEECs). Retrieved December 20, 2017 from https://www.veet.vic.gov.au/Public/Public.aspx?id=Certificates(VEECs).

Essential Services Commission. (n.d.). Search the Register of Victorian Energy Efficiency Certificates. Retrieved December 20, 2017 from https://www.veet.vic.gov.au/Public/PublicRegister/Search.aspx.

Essential Services Commission. (n.d.). Audit and Compliance. Retrieved December 20, 2017 from https://www.veet.vic.gov.au/public/Public.aspx?id=AuditandCompliance.

European Energy Exchange AG (EEX). (2017). European emission allowances | Global environmental exchange. Retrieved December 20, 2017 from https://www.eex.com/en/market-data/environmental-markets/spot-market/european-emission-allowances#!/2017/12/08.

EuroWhiteCert Project. (n.d.). EuroWhiteCert Project: Interaction and integration of White Certificates with other policy instruments. Recommendations & guidelines for decision makers. Retrieved December 20, 2017 from https://ec.europa.eu/energy/intelligent/projects/sites/iee-projects/files/projects/documents/eurowhitecert_guideliness_for_policy_makers.pdf.

Evaluation Into Practice to Achieve Targets for Energy Efficiency (EPATEE). (2017). [ITALY] The Italian white certificates scheme (Meccanismo dei certificati bianchi). Retrieved February 15, 2018 from https://epatee.eu/sites/default/files/epatee_case_study_italy_white_certificates.pdf

Eversource Energy, The United Illuminating Company, Connecticut Natural Gas, and Southern Connecticut Gas. (2017, March 1). 2017 Annual update of the 2016-2018 Conservation & Load Management Plan. Retrieved December 20, 2017 from http://www.ct.gov/deep/lib/deep/energy/conserloadmgmt/2017_Plan_Update.pdf.

Fogt, R. (2003, July 14). Re: How many barrels of crude oil in one MT? Retrieved January 23, 2018 from http://www.onlineconversion.com/forum/forum_1058197476.htm.

Friedman, B., Bird, B., and Barbose, G. (2009 July). Energy Savings Certificate Markets: Opportunities and implementation barriers. National Renewable Energy Lab (NREL). NREL/CP-6A2-45970. Retrieved January 11, 2018 from https://www.nrel.gov/docs/fy09osti/45970.pdf.

Gebhardt, S. (2017, December 8). Personal communication. (E. Aldrich, interviewer).

Gero, G. (2009, June 2). The Role of Carbon Offsets in Cap-and-Trade. Presentation from U.S. EPA SF_6 Emission Reduction Partnership Meeting, Chicago June 2, 2009 on behalf of Climate Action Reserve. Retrieved December 20, 2017 from https://docs.google.com/viewer?url=https%3A%2F%2Fwww.epa.gov%2Fsites%2Fproduction%2Ffiles%2F2016-02%2Fdocuments%2Fgero_carr_at_epa.pdf.

Giraudet, L.G. & Finon, D. (2015). European experiences with white certificate obligations: A critical review of existing evaluations. *Economics of Energy & Environmental Policy 4*(1): p. 113-130. From The International Association for Energy Economics. Retrieved December 19, 2017 from https://hal-enpc.archives-ouvertes.fr/hal-01016110/document.

Gould, K. (2017, November 28). Personal communication via email with E. Aldrich.

Green Energy Markets. (2017, November 10). ESC Market Prices. Retrieved December 20, 2017 from http://greenmarkets.com.au/resources/esc-market-prices.

Hamrin, J., Vine, E., & Sharick, A. (2007). The potential for Energy Savings Certificates (ESC) as a major tool in greenhouse gas reduction programs. Center for Resource Solutions. Retrieved December 20, 2017 from https://resource-solutions.org/document/the-potential-for-energy-savings-certificates-esc-as-a-major-tool-in-greenhouse-gas-reduction-programs/.

Harvey, F. (2017, December 19). China aims to drastically cut greenhouse gas emissions through trading scheme. The Guardian, U.S. Edition. Retrieved January 11, 2018 from https://www.theguardian.com/environment/2017/dec/19/china-aims-to-drastically-cut-greenhouse-gas-emissions-through-trading-scheme.

Hathaway, A. (2017, December 18). Personal communication via email with E. Aldrich.

Holt, E. (2010, February). Energy efficiency portfolio standards: A Connecticut case study. Ed Holt & Associates, Inc.

Independent Pricing and Regulatory Tribunal New South Wales (IPART). (2015). Registry user guide: Energy Savings Scheme, Greenhouse Gas Reduction Scheme. Retrieved January 29, 2018 from https://www.ess.nsw.gov.au/Registry/The_purpose_of_the_Registry.

Independent Pricing and Regulatory Tribunal New South Wales (IPART). (2016). NSW Energy Savings Scheme – Compliance and operation in 2015 – Annual report to the Minister, July 2016.

Retrieved December 20, 2017 from https://www.ipart.nsw.gov.au/Home/Industries/Energy-Savings-Scheme/NSW-Energy-Savings-Scheme-Compliance-and-Operation-in-2015-Annual-Report-to-the-Minister-July-2016.

Independent System Operator New England (ISO New England). (2017). Forward capacity market. Retrieved December 20, 2017 from https://www.iso-ne.com/markets-operations/markets/forward-capacity-market.

International Energy Agency (IEA). (2016). Energy policies of IEA countries. Italy. 2016 Review. Retrieved January 23, 2018 from https://www.iea.org/publications/freepublications/publication/EnergiePoliciesofIEACountriesItaly2016Review.pdf.

International Energy Agency (IEA). (2017a, November 3). White Certificate Scheme & Obligation: France. Retrieved December 20, 2017 from https://www.iea.org/policiesandmeasures/pams/france/name-22969-en.php.

International Energy Agency (IEA). (2017b, December 1). Addressing climate change: Policies and measures databases. Energy supply and consumption revolution strategy (2016-2030) in China. Retrieved January 11, 2018 from https://www.iea.org/policiesandmeasures/pams/china/name-162879-en.php?s=dHlwZT1jYyZzdGF0dXM9T2s,&return=PG5hdiBpZD0iYnJlYWRjcnVtYiI-PGEgaHJlZj0iLyI-SG9tZTwvYT4gJnJhcXVvOyA8YSBocmVmPSIvcG9saWNpZXNhbmRtZWFzdXJlcy8iPlBvbGljaWVzIGFuZCBNZWFzdXJlczwvYT4gJnJhcXVvOyA8YSBocmVmPSIvcG9saWNpZXNhbmRtZWFzdXJlcy9jbGltYXRlY2hhbmdlLyI-Q2xpbWF0ZSBDaGFuZ2U8L2E-PC9uYXY-.

International Energy Agency. (2017c). Energy Policies of IEA Countries – France 2016 Review. Retrieved February 22, 2018 from https://www.iea.org/publications/freepublications/publication/energy-policies-of-iea-countries---france-2016-review.html.

Jacobs, E. (2017, December 7). Personal communication via email with E. Aldrich.

Johnson, M., Perera, N., Beckett, T., Dyhr-Mikkelsen, K., and Togeby, M. (2013, August 16). International review of trading schemes for energy savings and carbon emission reductions. Report Commissioned by the World Bank. Produced by Ricardo AEA and Ea Energy Analysis. Retrieved December 20, 2017 from http://www.ea-energianalyse.dk/reports/1316_international_review_certificate_trading_schemes.pdf.

Kellen, P. (2015, November 5). Introduction to the National Energy Efficiency Registry. A presentation from The Climate Registry.

Li, M., Stanton, P. (2016, June). The National Energy Efficiency Registry: Why NEER Now? 2016 ACEEE Summer Study on Energy Efficiency in Buildings. Retrieved January 17, 2018 from https://aceee.org/files/proceedings/2016/data/papers/9_810.pdf.

Loper, J., Harris, J., Ungar, L., Capanna, S., Devranoglu, S., & Alliance to Save Energy. (2008). Deal or no deal? Pros and cons of trading under an energy efficiency resource standard. 2008 ACEEE Summer Study on Energy Efficiency in Buildings. Retrieved December 20, 2017 from http://aceee.org/files/proceedings/2008/data/papers/5_681.pdf.

Lovins, A. (1985). Saving gigabucks with Negawatts. Public Utilities Fortnightly Magazine. Retrieved February 15, 2018 from https://www.fortnightly.com/fortnightly/1985/03/saving-gigabucks-negawatts-1985.

Maddox, R.A. (2017, December 14). Personal communication. (E. Aldrich, interviewer).

Martin, J. (2017, November 8). Personal communication. (E. Aldrich, interviewer).

McCarthy, J.E., Ramseur, J.L., Leggett, J.A., Tsang, L., and Shouse, K.C. (2017, December 4). EPA's Clean Power Plan for existing power plants: Frequently asked questions. 7-5700, R44341.

Ministry of Ecological and Solidary Transition. (2016, December 5). Energy Savings Certificates Scheme. Retrieved December 20, 2017 from https://www.ecologique-solidaire.gouv.fr/index.php/dispositif-des-certificats-deconomies-denergie.

Ministerial Decree 11/01/2017. (2017, April). Gazetta Ufficiale Della Repubblica Italiana. *Serie General* 78.

Minnesota Pollution Control Agency. (n.d.). Mass-based versus rate based. Retrieved January 20, 2018 from https://www.pca.state.mn.us/air/mass-based-versus-rate-based.

Mundaca, L. (2007, February). Transaction costs of Tradable White Certificate schemes: The Energy Efficiency Commitment as case study. *Energy Policy 35*: p. 4340-4354.

Nadel, S., Cowart, R., Crossley, D., & Rosenow, J. (2017). Energy saving obligations across three continents: contrasting approaches and results. ECEEE 2017 Summer Study—Consumption, Efficiency & Limits.

National Energy Efficiency Registry (NEER). (2017b, October). National Energy Efficiency Registry: State-specific roadmaps. Retrieved January 17, 2018 from www.naseo.org/data/sites/1/documents/publications/NEER-roadmap-allstates.pdf.

National Energy Efficiency Registry (NEER). (2017a, July). National Energy Efficiency Registry Principles and Operating Rules. Version 1.0. pp.173.

Natural Resources Defense Council (NRDC). (2015, August). Understanding the EPA's Clean Power Plan. Retrieved January 12, 2018 from https://www.nrdc.org/file/3942/download?token=7Yn2oEGg.

Nelson, K. (2012, October). The state of the CT RPS: Where, what kind, and how much? Presented to: Connecticut Business and Industry by Element Markets. Retrieved December 20, 2017 from http://www5.cbia.com/events/wp-content/uploads/2012/10/Panel-III-130-p-m-Ken-Nelson.pdf.

Nemtzow, D. & Siddiqui, O. (2008). Giving credit where credit is due: Energy efficiency in CO_2 emissions trading. 2008 ACEEE Summer Study on Energy Efficiency in Buildings. Retrieved December 20, 2017 from https://aceee.org/files/proceedings/2008/data/papers/8_555.pdf.

New England Power Pool (NEPOOL) GIS. (2017). Number of certificates by RPS eligibility during 2017 Quarter 2. Retrieved January 11, 2018 from https://www1.nepoolgis.com/myModule/rpt/myrpt.asp?r=107&TabName=RPS.

New South Wales Government. (2015, April). Review of the NSW Energy Savings Scheme – Part 2: Options Paper. Retrieved December 20, 2017 from http://www.resourcesandenergy.nsw.gov.au/__data/assets/pdf_file/0010/558865/part-2-options-paper-april-2015.pdf.

NV Energy. (2017, March 30). Portfolio Standard Annual Report: Compliance year 2016. Docket No. 17-03044. Inclusive of Nevada Power Company and Sierra Pacific Power Company. Retrieved December 20, 2017 from https://www.nvenergy.com/publish/content/dam/nvenergy/brochures_arch/cleanenergy/2016ComplianceReport.pdf.

Ola, D. for PV Tech. (2016, November 10). Nevada votes to end the NV Energy monopoly. Retrieved December 20, 2017 from https://www.pv-tech.org/news/nevada-votes-to-end-nv-energy-monopoly.

Oppermann, M. (2017, December 7). Personal communication via email with E. Aldrich.

O'Shaughnessy, E., Heeter, J., Cook, J. & Volpi, C. (2017, October). Status and trends in the U.S. Voluntary Green Power Market. National Renewable Energy Laboratory Technical Report, NREL/-TP-6A20-70174. Retrieved December 20, 2017 from https://www.nrel.gov/docs/fy18osti/70174.pdf.

Pela, A. (2015). The Italian White Certificate Scheme: Cost of EEO scheme & cost recovery mechanism. Presentation from Gestore Servizi Energetici (GSE). Retrieved December 19, 2017 from http://enspol.eu/sites/default/files/The%20Italian%20White%20Certificate%20Scheme%2C%20Alberto%20Pela%20%E2%80%93%20GSE.pdf.

Pennsylvania Public Utilities Commission (PUC). (n.d.). Energy Efficiency and Conservation (EE&C) Program. Retrieved December 20, 2017 from http://www.puc.state.pa.us/filing_resources/issues_laws_regulations/act_129_information/energy_efficiency_and_conservation_ee_c_program.aspx.

Peskoe, A. (2015, October 20). Harvard Environmental Policy Initiative: Emission Rate Credits (ERCs) in the Clean Power Plan. An FAQ for states and stakeholders. Harvard Law School, Environmental Law Program. Retrieved January 16, 2018 from www.environment.law.harvard.edu/.../Emission-Rate-Credits-in-the-Clean-Power-Plan.pdf.

PJM Interconnection & Environmental Information Services. (n.d.). Generation Attribute Tracking System. Retrieved December 20, 2017 from https://gats.pjm-eis.com/GATS2/PublicReports/GATSCertificatesStatistics/Filter.

Ramseur, J.L. & McCarthy, J.E. (2016, September 27). EPA's Clean Power Plan: Highlights of the Final Rule. Congressional Research Service, 7-5700, R44145.

Ramseur, J. & Tsang, L. (2016, August 29). EPA's Clean Energy Incentive Program: Background and legal developments. Congressional Research Service, R44607.

RE100. (n.d.). 119 RE100 companies have made a commitment to go '100% renewable'. Read about the actions they are taking and why. Retrieved January 11, 2018 from http://there100.org/companies.

Regional Greenhouse Gas Initiative (RGGI). (n.d.). Auction results. Retrieved December 20, 2017 from https://www.rggi.org/market/co2_auctions/results.

Regional Greenhouse Gas Initiative (RGGI). (2007, October). Overview of RGGI CO_2 Budget Trading Program. Retrieved December 20, 2017 from http://www.rggi.org/docs/program_summary_10_07.pdf.

Regulatory Assistance Project. (2012, June). Best practices in designing and implementing energy efficiency obligation schemes. Research report: Task XXII of the International Energy Agency Demand Side Management Program. Retrieved December 20, 2017 from http://www.raponline.org/wp-content/uploads/2016/05/rap-ieadsm-bestpracticesindesigningandimplementingenergyefficiencyobligationschemes-2012-may.pdf.

Rotiroti, D. (2017, October 19). Energy Efficiency in Italy: Regulatory Framework and White Certificate Scheme.

S&P Global Platts. (2014, May 5). Rise in China's coal-fired capacity in 2014, 2015 may not boost thermal coal prices: UBS. Retrieved January 11, 2018 from https://www.platts.com/latest-news/coal/singapore/rise-in-chinas-coal-fired-capacity-in-2014-2015-21573872.

Save American Energy Act of 2009, S.548 introduced March 9, 2009 by Sen. Charles Schumer [D-NY]. Retrieved December 20, 2017 from https://www.congress.gov/bill/111th-congress/senate-bill/548.

Sherrick, J. (2017, November 29). Personal communication. (E. Aldrich, interviewer).

Standards of performance for new stationary sources, 42 USC §7411, Chapter 85 – Air pollution prevention and control Subchapter I – programs and activities, Part A- Air quality and emission limitations (2017, May 10).

Stanton, P. (2017, November 10). Personal communication. (E. Aldrich, interviewer).

Stavins, R. (2018, January 7). What should we make of China's announcement of a national CO_2 trading system? Robert Stavin's Blog. Retrieved January 20, 2018 from http://www.robertstavinsblog.org/2018/01/05/make-chinas-announcement-national-cap-trade-system/.

Sterling Planet. (n.d.) White Tags Explained. Retrieved February 28, 2018 from https://sterlingplanet.com/WhatWeDo/WhiteTags.aspx.

Sterling Planet. (2011, September 19). Sterling Planet, DTE Energy launch White Tags® program. Retrieved December 20, 2017 from http://sterlingplanet.com/ResourceCenter/NewsRoom/tabid/59/post/sterling-planet-dte-energy-launch-white-tags-program/Default.aspx.

Sterling Planet. (2012, June 12). Sterling Planet completes nation's first White Tags® transaction. Retrieved December 20, 2017 from http://www.sterlingplanet.com/ResourceCenter/NewsRoom/tabid/59/post/sterling-planet-completes-nation-s-first-white-tags-transaction/Default.aspx.

Sterling Planet. (2013, February 27). General Motors and Sterling Planet complete First White Tags® transaction. Retrieved December 20, 2017 from http://www.sterlingplanet.com/ResourceCenter/NewsRoom/tabid/59/post/general-motors-and-sterling-planet-complete-first-white-tags-transaction/Default.aspx.

Sullivan, D. (2015a, September 29). Emission Rate Credits in the Clean Power Plan. Retrieved from Natural Resource Defense Council, Expert Blog, December 21, 2017 from https://www.nrdc.org/experts/dylan-sullivan/emission-rate-credits-clean-power-plan.

Sullivan, D. (2015b, September 29). Measuring energy efficiency in EPA's Clean Power Plan. Retrieved from Natural Resource Defense Council, Expert Blog, December 21, 2017 from https://www.nrdc.org/experts/dylan-sullivan/measuring-energy-efficiency-epas-clean-power-plan.

Sullivan, D. (2017, December 1). Personal communication. (E. Aldrich, interviewer).

Sustainable IT: The Carbon Report. (2015, December 7). Greenhouse gas emissions figures for GRI and CDP reporting for the financial year ending 30 September 2015. Reunert Limited. Retrieved February 12, 2018 from https://www.reunert.com/downloads/carbon-footprint-reports/2015/2015-Reunert-carbon-report-data-tables.pdf.

Terna Group. (2013, December 31). General Data: Population, income and energy consumption in Italy. Retrieved February 12, 2018 from https://docs.google.com/viewer?url=http%3A%2F%2Fdownload.terna.it%2Fterna%2F0000%2F0525%2F78.pdf.

The energy companies' energy savings effort, The Minister for Energy, Utilities and Climate – The network and distribution companies within the fields of electricity, natural gas, district heating and oil (incl. Danish Energy Association, HMN GasNet, Danish Gas Distribution, NGF Nature Energy, Danish District Heating Association, Association of Danish CHP Plants and Danish Oil Industry Association), Dec. 16, 2016.

Tierney, S., Hibbard, P., & Okie, A. of Analysis Group, Inc. (2011, June 30). Solar Development Incentives: Status of Colorado's Solar PV Program, practices in other states and suggestions for next steps. Retrieved December 20, 2017 from http://www.analysisgroup.com/uploadedfiles/content/insights/publishing/2011_ag_final_report_colorado_pv_programs.pdf.

Togeby, M., Dyhr-Mikkelsen, K., and James-Smith, E. (2007, November). Design of White Certificates: Comparing U.K., Italy, France, and Denmark. Produced by Ea Energy Analysis. Retrieved December 20, 2017 from http://www.ea-energianalyse.dk/reports/710_White_certificates_report_19_Nov_07.pdf.

Trauchessec, E. (2018, March 21). Personal communication (E. Aldrich, interviewer).

Tsang, L. (2017, November 13). EPA proposes to repeal the Clean Power Plan. Congressional Research Service, Legal Sidebar, 7-5700, LSB10016.

Tsang, L. & Wyatt, A. (2017, March 8). Clean Power Plan: Legal background and pending litigation in *West Virginia v. EPA*. Congressional Research Service, 7-5700, R44480.

Ufner, J. & Igleheart, A. (2017, November 14). EPA extends public comment period for rollback of Clean Power Plan. National Association of Counties blog. Retrieved December 22, 2017 from http://www.naco.org/blog/epa-extends-public-comment-period-rollback-clean-power-plan.

U.K. Committee on Climate Change. (2016, February 16). 2010 to 2015 government policy: energy demand reduction in industry, business, and the public sector. Appendix 3: CRC Energy

Efficiency Scheme. Department for Environment, Food & Rural Affairs, Department of Energy and Climate Change, and Environment Agency. Retrieved January 11, 2018 from https://www.gov.uk/government/publications/2010-to-2015-government-policy-energy-demand-reduction-in-industry-business-and-the-public-sector/2010-to-2015-government-policy-energy-demand-reduction-in-industry-business-and-the-public-sector#appendix-3-crc-energy-efficiency-scheme.

U.K. Department for Business, Energy & Industrial Strategy (BEIS). (2017a). Research and analysis: Greenhouse gas reporting: Conversion factors 2017. Retrieved February 12, 2018 from https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2017.

U.K. Department for Business, Energy & Industrial Strategy (BEIS). (2017b). Energy Trends December 2017, Section 5: Electricity. Retrieved February 12, 2018 from https://docs.google.com/viewer?url=https%3A%2F%2Fwww.gov.uk%2Fgovernment%2Fuploads%2Fsystem%2Fuploads%2Fattachment_data%2Ffile%2F669750%2FEnergy_Trends_December_2017.pdf.

U.K. Department of Energy & Climate Change. (2014, April). U.K. National Energy Efficiency Action Plan. Retrieved December 20, 2017 from https://ec.europa.eu/energy/sites/ener/files/documents/2014_neeap_united-kingdom.pdf.

U.K. Environment Agency. (2016, December 2). Energy savings opportunity scheme. Retrieved January 29, 2018 from https://data.gov.uk/dataset/energy-savings-opportunity-scheme.

U.S. Department of Energy (DOE). (n.d.). NV Energy (Northern Nevada) – SureBet Business Energy Efficiency Rebate Program. Retrieved December 20, 2017 from https://energy.gov/savings/nv-energy-northern-nevada-surebet-business-energy-efficiency-rebate-program.

U.S. Department of Energy (DOE). (n.d.). NV Energy – Energy Smart Schools Program. Retrieved December 20, 2017 from https://energy.gov/savings/nv-energy-energy-smart-schools-program.

U.S. Department of Energy (DOE). (n.d.). LED lighting. Retrieved January 11, 2018 from https://energy.gov/energysaver/led-lighting.

U.S. Energy Information Administration. (n.d.). Electric utility demand side management – Archive. Retrieved February 15, 2018 from https://www.eia.gov/electricity/data/eia861/dsm/.

U.S. Environmental Protection Agency/Office of the Chief Financial Officer. (2015). *FY 2016 EPA Budget in Brief*. EPA-190-S-15-001. Washington, D.C.: U.S. Environmental Protection Agency. Retrieved January 17, 2018 from https://www.epa.gov/sites/production/files/2015-02/documents/fy_2016_bib_combined_v5.pdf.

U.S. Environmental Protection Agency. (2015). *United States Environmental Protection Agency Fiscal Year 2016 Justification of Appropriation Estimates for the Committee on Appropriations*. EPA- 190-R-15-001. Washington, D.C.: U.S. Environmental Protection Agency. Retrieved January 17, 2018 from https://www.epa.gov/sites/production/files/2015-02/documents/epa_fy_2016_congressional_justification.pdf.

U.S. Environmental Protection Agency. (2016, June 27). FACTSHEET: Overview of the Clean Power Plan. Cutting carbon pollution from power plants. Retrieved January 10, 2018 from https://19january2017snapshot.epa.gov/cleanpowerplan/fact-sheet-overview-clean-power-plan_.html.

U.S. Environmental Protection Agency. (2018, January 9). Greenhouse gases equivalencies calculator—calculations and references. EPA, Energy and the Environment. Retrieved January 23, 2018 from https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references.

U.S. Environmental Protection Agency. (n.d.). FACTSHEET: The Clean Power Plan. Clean Energy Incentive Program.

U.S. Federal Energy Regulatory Commission. (2017, March 28). Review of Federal Energy Commission Agency actions pursuant to Executive Order 13783, Promoting Energy Independence and Economic Growth. Retrieved December 22, 2017 from https://www.ferc.gov/legal/staff-reports/2017/EO-13783.pdf.

U.S. Government Publishing Office. (2017, October 16). 82 FR 48035 – Repeal of carbon pollution emission guidelines for existing stationary sources: Electric utility generating units. Federal Register, 40 CFR 60. Retrieved December 22, 2017 from https://www.gpo.gov/fdsys/search/pagedetails.action?granuleId=2017-22349&packageId=FR-2017-10-16&acCode=FR&collectionCode=FR.

Valdmanis, R. (2017, April 6). States challenge Trump over Clean Power Plan: 17 states are objecting to the EPA's request to delay legal proceedings of the climate rule. Scientific American. Retrieved January 17, 2018 from https://www.scientificamerican.com/article/states-challenge-trump-over-clean-power-plan/.

Vine, E. (2017, December 4). Personal communication. (E. Aldrich, interviewer).

Vivanco, D.F., Kemp, R., & van der Voet, E. (2016, July). How to deal with the rebound effect? A policy-oriented approach. *Energy Policy 94*: p.114-125. Retrieved December 20, 2017 from https://doi.org/10.1016/j.enpol.2016.03.054.

Wall Street Journal Editorial Board. (2017, October 8). Pruitt's clean power break. Retrieved January 10, 2018 from https://www.wsj.com/articles/pruitts-clean-power-break-1507489415.

Walton, R. (2018, January 12). EPA provides details on new listening sessions for Clean Power Plan repeal. Utility Dive. Retrieved January 17, 2018 from https://www.utilitydive.com/news/epa-provides-details-on-new-listening-sessions-for-clean-power-plan-repeal/514687/.

West Virginia et al v. EPA, no. 15-1363 (D.C. Circuit docketed October 23, 2015). On Petition for Review of Final Agency Action of the United States Environmental Protection Agency 80 Fed. Reg. 64, 622. Retrieved January 10, 2018 from https://docs.google.com/viewer?url=http%3A%2F%2Fwww.ago.wv.gov%2Fpublicresources%2Fepa%2FDocuments%2FOpening%2520Core%2520Brief%2520-%2520file-stamped%2520(M0119247xCECC6).pdf.

Wirtshafter, R.M., Grover, S., Dickerson, C.A., Rubin, R., Takanishi, W., & Cole, J. (2012). The regulatory relationship between free ridership and equity for public good programs. 2012 ACEEE Summer Study on Energy Efficiency in Buildings. Retrieved December 20, 2017 from https://aceee.org/files/proceedings/2012/data/papers/0193-000366.pdf.

Wood, J. and Jozto, F. (2009, October 10). Price floors for emissions trading. Research report no. 36. ISSN 1835-9728. Environmental economics research hub in the School of Economics and Government, Australian National University. Retrieved January 11, 2018 from https://ageconsearch.umn.edu/bitstream/94885/2/EERH_RR36.pdf.

Yang, Y. (2016, September 22). Development and reform commission released "the use of compensation for the use of energy and trading system pilot program" will be carried out in four provinces to use energy trading pilot (translation from Chinese). Ecological Civilization of China: China Ecological Civilization Research and Promotion Association. Retrieved January 11, 2018 from http://www.cecrpa.org.cn/sxyw/zx/9029.htm.

Appendix A: Energy Efficiency Resource Standards for U.S. States

This table contains a summary of data from the detailed descriptions of individual state programs from the DSIRE website. The programs vary in their strategy and stringency but are reported as similarly as possible for the purposes of comparison in this paper.

State	Electric Sales Reduction	Peak Demand Reduction	Natural Gas Sales Reduction
Arkansas	1% by 2019 (compared to 2015)		0.5% by 2019 (compared to 2015)
Arizona	22% by 2020	Up to 2%	6% by 2020
California	10% by 2024	10% by 2020	20% by 2020
Colorado	5% by 2018 (compared to 2006)	5% by 2018 (compared to 2006)	5% by 2018 (compared to 2006)
Connecticut	4% by 2010 (compared to 2006)		
Delaware	15% by 2015 (compared to 2007)	15% by 2015 (compared to 2007)	15% by 2015 (compared to 2007)
Florida	991 GWh (compared to 2015)	927 MW summer peak reduction, 877 MW winter peak reduction by 2024	
Hawaii	30% by 2030 (compared to 2007)		
Iowa	1.10-1.19% by 2018 (compared to 2014)	436-504 MW by 2018	0.64-1.28% by 2018
Illinois	Ramping up to 2% per year by 2016	.10% each year to 2019	Ramping up to 7.1% per year by 2019
Indiana	Ramping up to 2% per year by 2019 based on benchmark by previous three year average		
Massachusetts	2.93% by 2016		1.24% by 2016
Maryland	2% by 2017		
Maine	30% by 2020	100 MW by 2020	30% by 2020
Michigan	Ramping up to 1% per year from 2012 on, based on previous year baseline		Ramping up to 0.75% per year from 2012 on, based on previous year baseline
Minnesota	1.5% per year, beginning in 2010		1.5% per year, beginning in 2010

Missouri	Ramping up to 1.9% in 2020 based on annual sales	1% annual peak reduction	
New Hampshire	1.3% by 2020 (compared to 2014)		0.8% by 2020 (compared to 2014)
New Mexico	8% by 2020 (compared to 2005)		
New York	548,687 MWh by 2018 (compared to 2015)		1,737,607 Dth by 2018 (compared to 2015)
Ohio	Ramping up to 8.2% by 2020 and 22% by 2027	Ramping up to 7.75% by 2020	
Pennsylvania	1.6-5% by 2021 (compared to 2010)	4.5% by 2013 (compared to 2008)	
Rhode Island	2.6% by 2017 (compared to 2012)	27.3% summer and winter peak reduction	1.10% by 2017 (compared to 2012)
Texas		30% reduction in annual growth, 0.4% total peak demand thereafter	
Virginia	10% by 2022 (compared to 2006)		
Vermont	321,800 MWh by 2017 (compared to annual incremental sales 2015-2017)		
Washington	0.4-1.5% by 2015		
Wisconsin	32,197 GWh by 2018		1,588 MMth by 2018

The Energy Policy Institute is an integral part of the Center for Advanced Energy Studies, which is a public/private partnership between the Idaho National Laboratory, Boise State University, the University of Idaho, Idaho State University, and private industry.

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