



A study of carbon offsets and RECs to meet Boston's mandate for carbon neutrality by 2050

Research conducted as part of MIT's Sustainability Lab Class

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1. Introduction

This report provides science-based criteria for evaluating the effectiveness of offsets and RECs (renewable energy certificates) and details select types of carbon offset opportunities, including advantages and risks of each, design and implementation strategies, and case studies on entities (universities, corporations and other cities) which have undertaken significant carbon offset policy initiatives. This report is the final deliverable of an MIT Sloan Sustainability Lab team partnering with BU's Institute for Sustainable Energy (ISE) over the spring 2018 term. The goal of this report is that it will inform ISE's final, comprehensive report for the City of Boston, and, ultimately, that these ideas would help the City of Boston reach its goal of net zero Scope 1 and 2 greenhouse gas emissions by 2050 through indirect mechanisms, in addition to other direct emission reduction mechanisms.

Offsets and RECs are flexible and useful tools for reducing Boston's carbon footprint, but they come with some controversy and must be used carefully to ensure credible carbon reductions. This report begins by providing Boston with clear definitions of these tools to distinguish their appropriate scope of use, and an overview of the controversy surrounding offsets and RECs and how the city may ease these concerns through intentional design of its initiative. Next, we detail common types of offsets and the advantages or risks associated with each type's credibility and implementation. The fourth section of this report provides Boston with an overview of the market for offsets and RECs as well as detailed summary of various offset rating methodologies that could be adopted by the city. The remaining two sections highlight interesting case studies to illustrate first, how Boston could tailor the type of offset or RECs it choose to invest in to suit the city's circumstances, and second how the design of the program itself, in terms of volume, timing, and funding mechanism, can be optimized to meets Boston's objectives.

2. The purpose of offsets and RECs

Offsets and RECs may at first seem like similar concepts, but they serve very distinct purposes when it comes to compensating for indirect emissions of greenhouse gases (GHGs). This section first provides Boston with working definitions for both types of crediting mechanisms and compares and contrasts their structure and purpose to enable Boston to incorporate these tools into its planning appropriately. Next, it explores the controversy around the use of these crediting mechanisms and outlines strategies that Boston could employ to avoid common pitfalls. Finally, this section details criteria which Boston should apply in evaluating credible offsets and RECs.

2.1. Definitions

2.1.1. Defining a carbon offset

A carbon offset represents a metric ton of verified carbon emissions that are avoided or reduced as a result of a discrete, external project. The certification confirming the emissions reduction can be sold allowing the purchaser to claim the reductions as their own, netting out or offsetting carbon emissions for which the purchaser is responsible.¹ As defined by the GHG Protocol, an offset is “a specific activity or set of activities intended to reduce GHG emissions, increase the storage of carbon, or enhance GHG removals from the atmosphere.”² As illustrated in the figure 1 below, offsets may be used to address Scope 1, 2, or 3 emissions and are often used for meeting voluntary commitments where it is not feasible to lower direct or indirect emissions.³

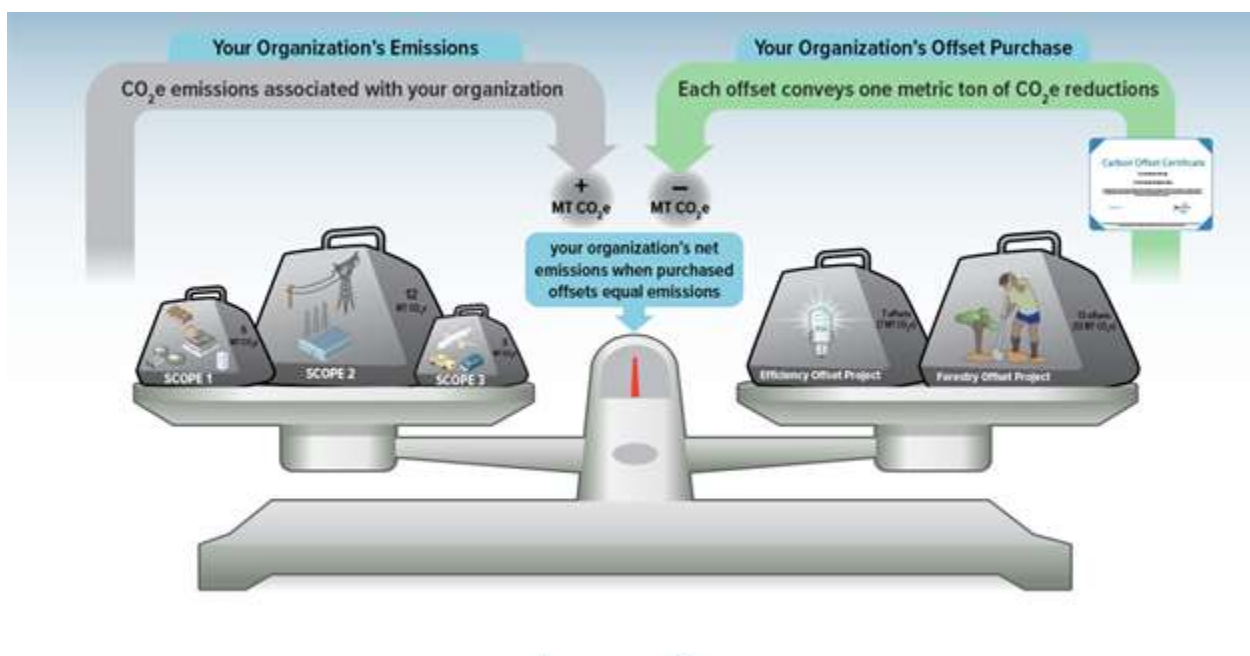


Figure 1: Illustration of emissions and offsets of one organization⁴

2.1.2. Defining a REC

A REC is an “environmental commodity” that legally bundles the ownership of all environmental and social attributes associated with the generation of one megawatt-hour (MWh) of renewable

¹ "Offsets and RECs: What's the Difference? | Green Power Partnership." 7 Mar. 2018, <https://www.epa.gov/greenpower/offsets-and-recs-whats-difference>. Accessed 17 May. 2018. (hereafter “EPA Green Power Partnership, 2018”)

² "The Greenhouse Gas Protocol - GHG Protocol." http://www.ghgprotocol.org/sites/default/files/ghgp/standards/ghg_project_accounting.pdf. Accessed 17 May. 2018. (hereafter “WRI GHG Protocol, 2004”)

³ EPA Green Power Partnership, 2018

⁴ EPA Green Power Partnership, 2018

energy.⁵ RECs are created when qualifying renewable energy is actually generated (as opposed to being based on installed capacity). For example, a homeowner with solar in Massachusetts generates RECs (specifically, solar RECs or “S-RECs”) when their panels produce into the grid. The homeowner can then choose to sell these to conventional fossil fuel-based generators who are required to buy a certain number of RECs to satisfy the state’s Renewable Portfolio Standards (RPS) which requires that a certain percentage of total generation come from renewable sources. The RECs are the mechanism that prove this portion of renewable generation.

There are many environmental and social attributes of renewable energy, but RECs are most frequently desired for the right to claim zero-carbon, or emissions-free electricity. RECs can be purchased either separately from or together with the underlying electricity which increases consumer’s choice about the source of their electricity regardless of the local electricity generation portfolio in their region. As a regulated and verified legal certificate, RECs serve as the “currency for renewable energy claims in both compliance and voluntary markets” in North America.⁶ The REC serves to track the claim to the carbon-free attribute of the renewable energy generation to ensure that the credits are not double counted, and therefore can be applied to reduce Scope 2 emissions. Though also used to reduce GHGs, RECs are distinct from carbon offsets. The following section highlights the key differences between these mechanisms.

2.1.3. Key differences between offsets and RECs

Both offsets and RECs can be used to reduce the owner’s carbon footprint. However, these crediting mechanisms must satisfy different criteria and therefore represent different things with different appropriate uses. The table 1 below highlights some of these key differences in certification, benefits, measurements, and applications.⁷ Differences in certification criteria and market structure are also detailed further in the following sections. RECs cannot be converted to offsets or vice-versa. This is because REC generating projects do not meet the offset requirement to have caused reduction in emissions beyond a business-as-usual scenario, and offsets do not convey ownership of the non-GHG benefits that are bundled in a REC.⁸

⁵ "Renewable Energy Certificates, Carbon Offsets, and Carbon Claims." <https://resource-solutions.org/wp-content/uploads/2015/08/RECsOffsetsQA.pdf>. Accessed 17 May. 2018. (hereafter “CRS Best Practices 2012”)

⁶ CRS Best Practices, 2012

⁷ Table 1 includes information from the following sources: CRS Best Practices, 2012; EPA Green Power Partnership, 2018.

⁸ This criteria is called “additionality”, see Section 2.3.2 for detailed discussion of these criteria.

Table 1: Key differences between offset and REC

<u>Topic of Difference</u>	<u>Offset</u>	<u>REC</u>
Purpose of Crediting Mechanism	Provide support for emission reduction activities through supplemental revenue that increases the financial viability and thus feasible scope of GHG mitigation projects	Provide mechanism to drive market demand for renewable energy and increased rates development
Appropriate GHG accounting application	May be credited towards the owner's scope 1, 2, or 3 emissions	May be credited towards the owner's scope 2 emissions from electricity usage only ⁹
Measurement Unit	Metric tons of CO2 or CO2 equivalent	Megawatt hours
Types of qualifying projects	Any project that is certified to reduce or avoid emissions including projects devoted to: <ul style="list-style-type: none"> · Energy efficiency · Renewable energy · Carbon capture and storage · Methane or industrial gas mitigation 	Renewable energy generation projects
Rights conveyed	Right to claim reducing or avoiding GHG emissions outside the owner's operations	Right to claim use of zero-emission electricity, or to avoid the emissions associated with conventional electricity use
Certification criteria	Credible offsets will satisfy the P.A.V.E.R. ¹⁰ criteria and often additional criteria such as the generation of co-benefits and contemporary relevance	Not required to test additionality ¹¹

⁹ REC cannot be used to claim ownership of the GHG reductions that can be separated from the electricity sector because there is no criteria that RECs be generated from a beyond business as usual scenario (see further discussion of additionality in the next section). Therefore, RECs cannot be used to offset non-electricity related emissions. (CRS Best Practices, 2012, p. 3)

¹⁰ P.A.V.E.R. stands for Permanent, Additional, Verified, Enforceable, and Real. See Section 2.3 for a detailed discussion of these criteria.

¹¹ See, section II.B for more details.

Benefits conveyed	Greenhouse gas reductions	The full suite of social, economic and environmental benefits associated with renewable energy
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2.2. The debate over Offsets and RECs

Offsets and RECs have been criticized as ineffective mechanisms for reducing carbon emissions but, like any tool, offsets can be used effectively or ineffectively. The most common concerns fall into three buckets: the moral hazard of converting GHG reductions into a financial transaction, equity between regions that continue to emit and those that host offsets, and the credibility of GHG reductions. These concerns are valid, and offsets and RECs programs must be designed with a critical eye towards their intention in using these tools to drive change. This section provides context for Boston on the common pitfalls of offset and REC usage and suggests strategies that the city could employ to combat each concern.

First, offsets are often criticized for allowing their users to simply “pay for their sins.”¹²By converting emissions reduction into a financial transaction offsets can create a “moral hazard” by reducing the incentives for purchasers to take direct action to address the issues of GHG emissions which they are immediately responsible for. One strategy Boston could employ to address moral hazard is to use offsets to internalize the cost of carbon, providing a financial signal which can help incentivize further direct emissions reductions. If Boston’s offset program was designed such that the offset expense was paid by the same entities (sectors, departments, actors) who are responsible for generating emissions, then offsets can be an effective accelerator of internal direct emission reductions, because the more direct actions these entities take to reduce emissions, the fewer offsets they will need to purchase.

To be effective, this strategy requires the cost of offsets to appropriately reflect the “true” cost of emissions to society which is not guaranteed. Specifically, because offset and REC markets are voluntary, there is limited demand for these mechanisms and often limited willingness to pay for voluntary compliance. Both of these facts may act to depress the price of offsets or RECs below the true social value of the avoided emissions.¹³ Though assessing the true social cost of carbon is a complicated issue, far beyond the scope of this report, it is important context for designing programs that rely on offsets or RECs as Boston should be carefully about the price signal it sends through the offsets or RECs it chooses to purchase. Offsetting should not simply be a method of quickly and cheaply achieving legal carbon neutrality, but instead a way to drive change in the global market and incentivize direct emissions reductions. Many climate modeling scenarios show that global emissions must fall by at least 80% by 2050 in order to sustain less than a two

¹² For a city like Boston that would like to be perceived as a leader in carbon neutrality, the moral hazard of offsets could lead to reputational and political risks if they are used as mere substitutes of local direct reduction of emissions.

¹³ "Carbon Offset Guidance - Second Nature." 15 Sep. 2016, http://secondnature.org/wp-content/uploads/Second-Nature-Offset-Guidance_Draft.pdf. Accessed 17 May. 2018. (hereafter “Carbon Offset Guidance - Second Nature, 2016”)

degree change in global climates.¹⁴ This extent of GHG reductions can only occur with all parties doing their part to reduce their direct emissions so though offsets can play a helpful role in the short-run, the long-run objective should remain focused on driving global reductions. One way Boston could help ensure these objectives are met is to use the cost of offsets to internalize the expense of the damage done to society by the emissions Boston is responsible for.

Beyond the moral hazard concerns, it is also important to consider issues of equity. Offsets, especially in the US which is currently responsible for three times more emissions per person than the average global citizen,¹⁵ need to be targeted carefully. There is substantial reputational risk in implying that Boston, as a wealthier city, can buy the right to pollute from less well-off areas of the world.¹⁶ To address these concerns, Boston should consider how offsets can serve as a beneficial form of wealth redistribution. Some offset mitigation activities may not occur without the financial investments available from the sale of offsets. Furthermore, as discussed in the following sections, offsets can achieve quick reductions in emissions while more time-intensive and expensive internal initiatives are implemented to address direct emissions.

The third common critique of offsets and RECs focuses on whether or not offsets or RECs have indeed resulted in a real net reduction in emissions. Careful application and upholding of established criteria can help insure that offsets and RECs are indeed credible sources of carbon reductions. When used appropriately, offsets can become powerful tools that enable the efficient reduction of GHGs by targeting emissions globally that are either the most cost effective, time efficient, or produce additional benefits beyond the results of reducing the same amount of emissions locally.¹⁷ The following section discusses the criteria for establishing real, high quality offsets in more detail.

2.3. Criteria for a good Offset or REC

There is extensive literature available on the criteria that a credible carbon offset should satisfy. However, the extent to which these various criteria are weighed in the decision making process and, to some extent, which criteria are ultimately considered at all, vary widely and should be customized to satisfy Boston's objectives. In this section, we present a common framework for assessing credible offsets and RECs and then expand this traditional framework to include additional criteria which are supported by both research and their integration in recent offset and REC program designs.

¹⁴ Sterman, J. et al. Climate interactive: the C-ROADS climate policy model. *Syst. Dyn. Rev.* **28**, 295–305 (2012).

¹⁵ "6 Graphs Explain the World's Top 10 Emitters | World Resources Institute." 25 Nov. 2014, <https://wri.org/blog/2014/11/6-graphs-explain-world%E2%80%99s-top-10-emitters>. Accessed 17 May. 2018.

¹⁶ While classic economic theory would suggest that it is "optimal" to reduce emissions first where it is most cost effective to do so, there are significant political concerns of elitism (or even colonialism) to consider which can significantly shape the palatability thus feasibility of this approach. For instance, the debate raised of Larry Summer's "sarcastic" memo to the world bank in the 1990s highlights this controversy (see, <https://www.nytimes.com/1992/02/07/business/furor-on-memo-at-world-bank.html>).

¹⁷ Carbon Offset Guidance - Second Nature, 2016, p. 11.

The standard framework evaluates offsets relative to the P.A.V.E.R. criteria, which stands for Permanent, Additional, Verifiable, Enforceable, and Real. In the following sections, we explore each of these in detail and provide brief examples of projects that exemplify the criteria (see Section 3 for more details on types of offsets and their ability to satisfy these criteria). In addition, we supplement the traditional criteria, creating what we call the PAVER+ framework which adds the additional considerations of co-benefit generation and contemporary relevance as well as a few other less common, but potentially useful, criteria.

2.3.1. Permanent

Valid offsets must result in permanent reductions or sequestration of GHGs. The reductions must last in perpetuity without risk that they could become reversed. This is not equivalent to requiring the project itself to last forever. Because offsets are time-specific crediting mechanisms, permanence requires only that once the GHGs have been removed there is no (or reasonably low) risk that those removals could be reversed in the future.

Renewable energy projects for offsets or RECs address the concern of permanence easily. RECs are specific to renewable energy generation and once an MWh of electricity has been produced and the corresponding REC generated, there is no risk that that MWh could instead be produced by a more carbon intensive source.¹⁸ Other types of offsets however face greater difficulty satisfying this criteria. For instance, biological sequestration projects such as afforestation (discussed in more detail in Section 3) may not permanently store carbon if the trees succumb to disease or fire. Issuing insurance or preserving a buffer of unissued offsets are potential mechanisms for protecting against risk of impermanence (see Section 5 for further discussion of how this strategy has been implemented).

2.3.2. Additional

In order to truly serve as an offset, a project must result in reduction of GHGs beyond what would have occurred under the status quo (often referred to as beyond business-as-usual). The project must be spurred by the carbon market (i.e., without the potential of the revenues from selling the carbon credits it would not have happened) or otherwise mark a change from the 'usual' mode of operation. Importantly, this means that the project cannot be compelled by any existing or pending regulation. Additionality is a fundamental requirement that underpins an offset's ability to drive change in net emissions- emissions can only be "offset" if it is clear that but-for the specific project those emissions would have occurred. Additionality must always be tested in a credible manner and should never be assumed.¹⁹

There are several additionality tests which can be applied to gauge the credibility of a potential offset project. A simple and common test is an investment analysis or financial additionality test.

¹⁸ CRS Best Practices, 2012

¹⁹ CRS Best Practices, 2012.

This financial modeling exercise establishes whether the sale of the offsets is necessary for the project to occur. The sale of the credits does not need to be the only source of revenue, but it should constitute the marginal differentiator between viability and not. A second test, called a performance standard test, establishes a baseline for business-as-usual in the region and sector of the proposed project. Projects that over-perform this benchmark can then be considered additional as they result in savings beyond business-as-usual.²⁰ Other tests include confirming that the project was not already compelled by legal/regulatory restrictions, or in lieu of financial barriers other barrier tests identify hurdles in the market that prevent the project from occurring if it was motivated externally by the potential for generating carbon credits.²¹

Energy efficient cookstoves provide a simple example of an offset project with clear additionality. These projects typically provide efficient cookstoves to low-income individuals in the developing world, a capital expenditure they certainly could not have afforded themselves. These stoves require less fuel and burn much more efficiently reducing the emissions from food preparation and heating which the project can then bundle and sell as offsets, while providing financial and health benefits to their recipients. Without the ability to sell the offsets to pay for stoves, these projects would not be financially viable thus passing the additionality test.

RECs are not legally required to prove additionality, and are therefore substantially simpler to certify. However, this legal simplification has started to draw public scrutiny. There is an abundance of relatively low cost RECs available on the market due to renewable energy (particularly wind energy) increasingly becoming the most economically viable choice for electricity generation. These projects are developed as part of the business-as-usual scenario, profitable business ventures in their own right, and RECs are made available to the broader market as opposed to the demand for the REC itself driving the initial project development. As shown in figure 2 below, average REC prices peaked at around \$1.13/MWh in January 2014, but have since fallen such that in 2016 REC prices averaged around \$0.35/MWh.²²

²⁰ CRS Best Practices, 2012.

²¹ EPA Green Power Partnership, 2018.

²² Eric O'Shaughnessy, Jenny Heeter, Jeff Cook, and Christina Volpi, "Status and Trends in the U.S. Voluntary Green Power Market (2016 Data)", NREL, October 2017, p. 21. <https://www.nrel.gov/docs/fy18osti/70174.pdf> (Hereafter NREL, 2017.)

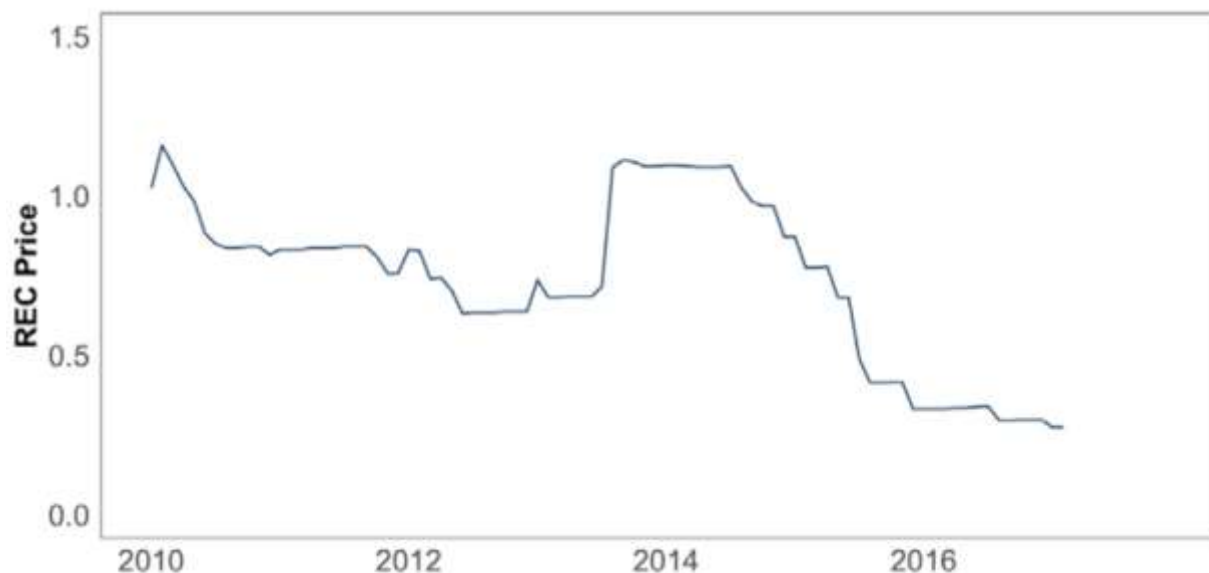


Figure 2: Evolution of REC prices²³

REC prices in Massachusetts tend to look substantially different than the national average. As shown in figure 3 below, prices of RECs (excluding S-RECs due to carve-out requirements which affect price) used for compliance with the state’s RPS have averaged closer to \$40/MWh, though they have fallen substantially in recent years.²⁴

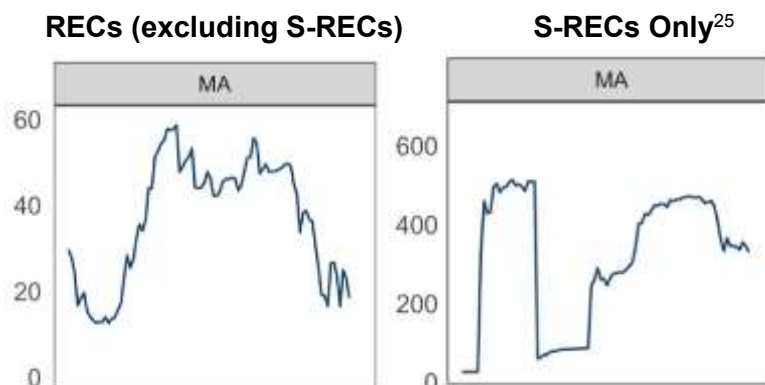


Figure 3: Average Price of RPS Compliance RECS in MA²⁶

While there is no legal difference between RECs, many entities have chosen to develop their own renewable projects instead of buying RECs on the existing market to insure that their investment adheres to the true intention of RECs, i.e., to drive further development of renewable energy

²³ NREL, 2017

²⁴ NREL, 2017, pp. 22-23.

²⁵ The price of S-RECs is often quite different from other RECs due to the higher cost of solar relative to wind and due to RPS program designs that often include “carve-outs” that require a certain portion of solar (S-RECs) to satisfy the standard. This increases market demand and drives up the price.

²⁶ NREL, 2017, pp. 22-23.

generation, and not just the letter of the law which could easily be satisfied by purchasing existing RECs, at low cost from already established developed projects.

2.3.3. Verifiable

Verification and measurement ensure that emissions reductions have truly occurred as the result of a discrete project, and that the volume of that reduction is matched appropriately to the issued offsets. As discussed in Section 5, there are numerous third-party project auditors and offset standards used in the market to verify that emission reductions are real and additional relative to the established but-for scenario, and to measure the volume of GHGs avoided or reduced from the project.

The data collection process for verification and measurement can be quite involved, and many credible rating agencies point to this difficulty to explain their high costs. For instance, in the cookstove example given above, it is necessary to confirm the actual rate of adoption of the new stoves and to what extent the usage behavior of the new stoves actually results in reduced emissions relative to the baseline scenario with the inefficient stoves before credible offsets can be issued for the project.

Renewable energy projects, whether for offsets or RECs, have a slight advantage here as the generation is easy to confirm, and while not perfectly precise it is widely accepted that regional emissions rates are an acceptable conservative benchmark to evaluate the GHG volumes that were displaced by the renewable generation.²⁷ RECs operate in a national market, so the renewable energy generated does not necessarily enter the same grid that the REC owner is connected to. Traditionally RECs allow the purchaser to reduce their GHG footprint by reducing the net electricity they are credited for consuming from their local grid, effectively reducing the owner's Scope 2 emissions. This footprint effect is dictated by how carbon intensive the grid is in the owner's region, and not how carbon intensive the grid is in the region where the REC was generated. New technology, however, may improve this accounting system by leveraging real time data on when renewables generate and what specific alternate generation they displace from the local grid.²⁸ This could allow owners to accurately identify the avoided emissions in remote grids instead of accounting for their local carbon intensities, and may allow for renewable investments to be targeted at the most carbon intensive regions more effectively. Section 3 includes a more detailed discussion of how different types of offsets vary in their relative ease or difficulty of verification.

²⁷ WRI GHG Protocol, 2004

²⁸ Companies such as WattTime, a recent acquisition of the Rocky Mountain Institute are promoting products that enable this level of data-driven energy management.

2.3.4. Enforceable

Offsets and RECs must be enforceable crediting mechanisms, structured as legal instruments with clear ownership and usage restrictions to ensure that the credits are not double counted. This is often dealt with through offset registries which serve as validation ledgers for the offset market, providing clear ownership and chain of custody so that only one entity can claim the emissions reductions and that they can only claim the reductions once.²⁹

As discussed in more detail in Section 3, several types of offsets such as industrial gas mitigation and reduced deforestation projects will not typically be accepted by credible rating agencies. This makes it much harder to enforce a claim to offset credits as they are not tracked and recorded in official registries. Other projects, such as renewable energy for RECs are easy to enforce and the REC ownership and claim process is clearly established and documented.

2.3.5. Real

Though seemingly obvious, high-quality offsets must result in real, net reductions in GHGs. The challenge here typically comes in the form of incomplete or flawed technical accounting. Incomplete accounting can be a quite subtle issue, as a carbon reducing project may have local benefits but increase or generate other carbon intensive activities elsewhere. This issue is referred to as “leakage,” as GHGs which were thought to have been reduced leak back into the atmosphere from other sources that were either directly or indirectly driven by the initial offset project itself.³⁰ Leakage can be obvious, as in geological sequestered gases that are ineffectively trapped and escape back to the surface, or subtle as in renewable energy installations that reduce the need to use gas plants as frequently (thus reducing emissions) but also reduce the overall efficiency of these gas plants which increasingly are called on to balance supply against the variability of the renewable’s production (thus reducing the savings). By its very nature, it is difficult to anticipate where or to what extent leakage will occur but by considering the full context of a proposed offset program and how all related industries and services may react to the change it is at least possible to assess the potent risk of leakage. When there is risk of leakage, the issued offsets should account for this increased risk through a buffer (generated but unclaimed credits) or insurance mechanisms and the issued offsets should be adjusted over time based on continued measurement and verification that quantify the magnitude of the effect.³¹

As with permanence, leakage has not often been a concern for renewable energy offsets or RECs. However, recent research has pushed to expand the accounting mechanisms used to improve their completeness. For instance, increasing the generation of renewable energy may be good for the US, but if an effect of this trend is to reduce prices for coal and increase volumes available for export then it is possible that some of the carbon benefits from greening the US grid might be

²⁹ Carbon Offset Guidance - Second Nature, 2016, p. 17.

³⁰ CRS Best Practices, 2012.

³¹ Carbon Offset Guidance - Second Nature, 2016, p. 15.

leaked back into the atmosphere if other countries consume more coal than they otherwise would have as a result.³²

2.3.6. Co-benefits

The City of Boston should consider co-benefits of offsets if they decide to implement them. This criteria guarantees the sustainability of the projects, while reducing the risk of negative externalities.

Offsets can also bring co-benefits related to sustainable and inclusive socio-economic development. Co-benefits refer to the additional benefits derived from offsets and policies to reduce GHG levels. A study developed by the Imperial College University demonstrated that for every 1 ton(tonne) of CO₂ emission avoided/removed through a carbon offset project, an additional value of US\$664 dollars is generated in economic, environmental, and social benefits for local communities around the world. The following figure 4 highlights the value generated by each type of benefit.³³



Figure 4: Value generated by each type of co- benefit in a carbon offset project

The following figure 5 shows the potential types of co-benefits of offset projects in businesses according to Ibid³⁴

³² Knittel, C.R., K. Metaxoglou, A. Soderbery, and A. Trindade (2017) "Does US Export Global Warming? Coal Exports and the Shale Gas Boom," mimeo, MIT CEEPR.

³³ International Carbon Reduction and Offset Alliance. (2016) "Unlocking the hidden value of carbon offsetting". Imperial College London University. Available at: http://www.icroa.org/resources/Documents/ICRO2834-Infographic_F.pdf

³⁴ Ibid.



Figure 5: Potential types of co-benefits of offset projects in businesses

Some of the positive effects include:³⁵

- **Health benefits:** Due to reduced pollution, offsets can provide access to clean and safe drinking water as well as cleaner air and other benefits. This drives improvements in human, animal, and plant life wellbeing and can generate significant savings in the public health system;
- **Environmental:** Reduction of air/water pollution, soil erosion, odor, noise, improved stormwater management, protected and enhanced biodiversity,³⁶ etc;
- **Social:** Improved living standards and comfort levels, access to public transportation, and improved access to green spaces;
- **Economic:** Reduction of housing and living costs, savings in fuel / electricity costs, reduced capital expense for new energy generation capacity, expanded employment opportunities, use of self-produced fertilizer, etc.

Some examples of offset projects' co-benefits include the following:³⁷

³⁵ "Carbon Offsets and Health Co-Benefits - Yale School of Forestry." 8 May. 2017, http://environment.yale.edu/docs/carb_policy_memo.pdf. Accessed 17 May. 2018.

³⁶ Kollmuss, A. et al. "Making Sense of the Voluntary Carbon Market: A Comparison of Carbon Offset Standards". WWF, Stockholm Environment Institute, Tricorona. (2008) (hereafter "WWF, SEI, Tricorona, 2008")

³⁷ International Carbon Reduction and Offset Alliance. (2016) "Valuing the additional benefits of carbon offsettings" Imperial College London University. Available at: http://www.icroa.org/resources/Pictures/ICRO2834%20Infographic_Benefits_HR.pdf

1. China's health benefits are estimated to offset the costs of climate policy. A study from MIT mentions that "a 4 percent reduction per year in carbon dioxide emissions should net \$339 billion in health savings in 2030"³⁸
2. Example of two offset projects and their added value as co-benefits:

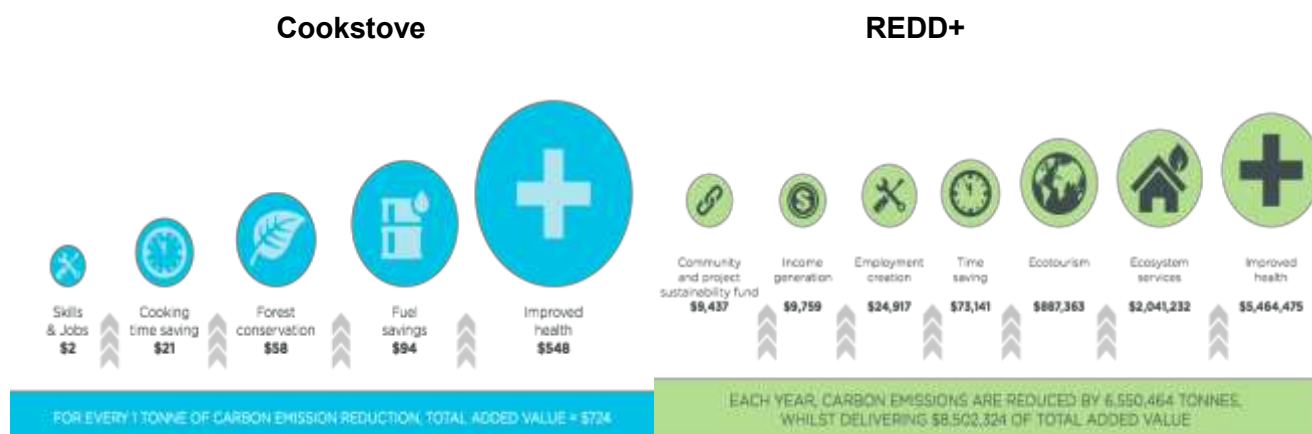


Figure 6: Added value of a cookstove project

Figure 7: Added value of a REDD+ project

In Figure 6, it can be seen how a project of cookstove generated considerable added value. For every 1 tonne of carbon emission reduction, there is an estimated total added value of USD\$724. In Figure 7, the added value of a REDD+ project is estimated in \$8,502,324 as co-benefits derived from each year carbon emissions reduction by 6,550,464 tonnes.

The platform Climate Interactive³⁹ presents examples and lessons of success stories of interaction between health and climate in cities around the world. One of the examples is Kyocera, a Japanese manufacturer that covers its buildings façades with Green Curtains to lower indoor temperatures, save energy, and reduce CO2 emissions.

However, the co-benefits cannot be assumed and they need to be carefully considered and measured as part of the project design. Offsets can also have negative impacts on local communities, as was the case in two carbon-offset projects funded by US companies in Guatemala and in Sri Lanka. In both of these cases, social equity in the region was affected.⁴⁰ This can happen when for instance, companies buy land in developing countries to do offset projects and this land is taken away from local communities that needed the land for agricultural purposes, such as crop cultivation. The projects also need to be careful to respect the local context in terms of communities' values, culture, native flora and fauna.

³⁸ "Study: Health benefits will offset cost of China's climate policy | MIT News." Accessed May 17, 2018. <http://news.mit.edu/2018/study-health-benefits-will-offset-cost-china-climate-policy-0423>.

³⁹ "Multisolving at the Intersection of Health and Climate - Climate Interactive." Accessed May 17, 2018. <https://www.climateinteractive.org/programs/multisolving/multisolving-at-the-intersection-of-health-and-climate/>.

⁴⁰ Society and Natural Resources (2009). "Carbon Offsets and Inequality: Social Costs and Co-Benefits in Guatemala and Sri Lanka" <https://www.tandfonline.com/doi/abs/10.1080/08941920802046858>

In order to guarantee sustainability and to avoid the harm of an offset project, there needs to be previous consultation with local communities and guarantee that they won't be socially, culturally or economically affected and that local biodiversity is not affected. There are also standards that verify the existence of co-benefits.⁴¹

2.3.7. Contemporary Relevance

Finally, high quality offsets need to consider the timing of their reductions and their assessment viability. The timing of an offset is important for two reasons. First, emissions are time-specific and it is therefore important that the offset be reducing or avoiding emissions during the same time period as the emissions it is used to offset were generated. There are three major concerns for using offsets and emissions from misaligned time periods. These concerns can be illustrated with a simple example, for instance consider an afforestation project where trees are planted as an offset and they will someday grow to capture carbon that is emitted today. However, applying this future offset to current emissions means that in the short-run (before the trees reach sufficient maturity) the total amount of GHGs in the atmosphere has increased which will exacerbate the effects of climate change and lead to other, potentially permanent, problems before the carbon can be captured by the planted trees. In addition, it is very difficult to accurately predict future sequestration rates (and thus difficult to validate the offset), if a drought were to slow the growth of the trees or a fire destroy them they would never successfully capture the carbon they were counted as offsetting. Similar afforestation, the ability to reduce emissions changes over time for many offsets. To avoid the concerns of increasing GHGs in the short run and to improve the accuracy of measured offsets, only concurrent reductions should be used as credits for immediate use as offsets. Third, timing is important considering the baseline scenario that is often used to evaluate the additionality of a project (i.e., the "business-as-usual" benchmark is usually evaluated over a finite time horizon). Once the valid time length for the baseline scenario has passed, no further offset credits can be issued without a new baseline assessment⁴² It is inappropriate to assume that simply because the emissions reductions were additional at the start of the project means that they will forever remain additional. For instance, an energy efficiency project may initially pass the financial test for additionality and thus be capable of producing offsets. However, as technology evolves and energy prices change that energy efficiency project may become economical on its own (no longer requiring the sale of offsets to justify its expense) at which point it cannot continue to generate offsets.

2.3.8. Additional Criteria

Many programs have considered additional criteria beyond what we have presented here. These criteria are interesting, and could be considered as part of the evaluation framework so we include them here for completeness, though we feel they are generally of secondary importance in the design and evaluation of a quality REC or offset program.

⁴¹ See section 4 on the market and standards of offsets.

⁴² WRI GHG Protocol, 2004, p. 133.

Project Transparency: Project details are known and readily available to the purchaser and all relevant stakeholders. Details could include the project's location, scope, duration, developer, criteria employed, community buy-in, measurement and verification practices, etc. While important, if credible rating agencies are used to verify projects this visibility becomes less crucial.

Formal Retirement of Credits: The objective of using an offset is to reduce the owners GHG footprint. In order to further ensure that these credits are not reused some programs have required that any offsets or RECs be formally "retired" once they have been used in GHG accounting. Offset or REC programs should always set aside used credits, but formal retirement may add an additional layer of credibility and mitigate risk of double counting.

3. Types of Offsets available

Our research has focused on several more common types of offsets. For Boston specifically, one or more of these offset types may be impossible to implement now, but given the ever changing landscape of offsets we tried to keep our research broad to encompass lots of possibilities. In this section we provide a brief overview of each type of offset, how difficult it is for projects of this type to satisfy the PAVER+ criteria, and any associated implementation risks.

3.1. Renewable Energy (offsets and RECs)

Renewable Energy projects are the biggest area of overlap, and thus potential of confusion, when evaluating the benefit of an offset versus a REC. Provided that a given renewable energy project satisfies the criteria for the generation of both crediting mechanisms, then a single MWh of renewable energy can either be claimed as a REC or the avoided emissions associated with that MWh can be claimed as an offset, but as discussed previously, because offsets and RECs convey different rights, it is not possible to convert RECs into offsets or vice versa.

The Regional Greenhouse Gas Initiative (RGGI) cap-and-trade system means that Boston must review traditional voluntary offsets or REC generating renewable projects carefully. Under a cap-and-trade system, renewable energy offsets or RECs will not reduce overall emissions unless there are set-aside allowances which lower the cap (reducing the number of permits available) by the size of the project. If the cap is not lowered by setting aside the credits, then renewable energy development simply frees up additional carbon credits, reducing the price of these credits and allowing other generation sources to continue to pollute. RGGI does include a voluntary renewable energy set-aside, so renewable energy projects (either for RECs or offsets) could be developed locally.⁴³

⁴³ CRS Best Practices, 2012.

Furthermore, Massachusetts has a Renewable Portfolio Standard (RPS) which drives the demand and prices for renewable energy in the state to some extent. Unlike other specific regulations, the presence of a RPS does not necessarily determine non-additionality for renewable energy projects.⁴⁴ In fact, some institutions have been able to ease the financial burden of project development by selling the RECs they generated into the local RPS driven market where prices were higher and purchasing replacement RECs from the broader market at a lower price. This allowed them to still contribute to new project development, insuring that the renewable generation as indeed additional, and achieving their goal of using 100% green electricity, all at a more manageable expense for their budget.⁴⁵

Overall, and as discussed in the previous section, renewable energy projects are typically able to satisfy the PAVER+ criteria easily (categorized as “Easy” in Table 2). Once a MWh has been produced from a renewable source, it cannot be produced instead with carbon intensive sources so the reduction is considered permanent. Though there are some additionality concerns in markets where renewable have become the cheapest generation option, financing is still often a barrier to in general, renewable projects are still beyond the “business as usual” scenario. Verifying production and enforcing ownership are straightforward given grid monitoring that is already required, and while leakage is a concern which should be re-evaluated over time, the current literature shows that this is not a significant, immediate concern for renewables. Co-benefits for renewable projects can vary depending on where they are sited. In regions where they allow early retirement of polluting generation sources like coal plants there may be health and environmental benefits, however if land is taken from other economically or environmental important sectors for renewable generation than the net benefits can be less clear. We rate the co-benefits as “moderate” accordingly, as thoughtful projects can still certainly satisfy this criteria.

3.2. Carbon Sequestration

Carbon sequestration is the act of removing carbon from the atmosphere and storing it securely. We examine two types of sequestration - biological and geological.

3.2.1. Biological

Biological carbon sequestration projects - most commonly taking the form of forestry - utilize biological entities to remove carbon from the atmosphere and store it in solid forms (i.e. trees).

These projects can be implemented in various ways:

- **Afforestation** - planting new trees where there were none originally
- **Reforestation** - re-planting trees where they once were
- **Enhancing trees’ carbon density** - achieved through improved forest management
- **Avoiding deforestation** - commonly referred to as “reduced emissions from deforestation and degradation” (“REDD”)

⁴⁴ CRS Best Practices, 2012.

⁴⁵ This option was discussed in meetings with MIT related to their collaborators in renewable energy development, see more detailed discussion of this project in section 6.1.

All of these forestation variants are direct counters to some of the biggest sources of carbon to our atmosphere - deforestation and land use. In 2010, the IPCC estimated that 11% of greenhouse gas emissions came from “forestry and other land use.” By economic sector, “Agriculture, Forestry, and other Land Use” accounted for 24% of greenhouse gas emissions.⁴⁶

Forestry offsets have a few clear advantages. Most noticeably, the concept of forestry offsets is pretty simple and readily explainable - a transparency that’s nice to have when enlisting public support. Given that, this type of offset usually has lower implementation and regulatory risks. Forestry also has numerous ecological co-benefits, such as soil, water, biodiversity enhancements, as well as human use benefits.

However, permanence can be an issue. If the trees were to be removed improperly, be it a natural cause like wildfire or a human cause like unsustainable timber services, the carbon sequestered by these trees is immediately released into the atmosphere. This brings the permanence of any forestry project into question, and strict requirements like land conservation can only go so far. Leakage can also be a concern - without proper assurances from land developers, it’s possible for any land originally reserved for offsets to be repurposed for logging.⁴⁷ That can result in more difficulty to verify and to enforce ownership of this type of offset.

In addition, assessing if the net carbon sequestration from a forestry offset is real can be moderately difficult. According to a MIT study dynamic lifecycle of wood bioenergy, replanting hardwood forests with fast-growing pine plantations actually raises the CO₂ impact of wood because the equilibrium carbon density of plantations is lower than natural forests. Further, projected growth in wood harvest for bioenergy would increase atmospheric CO₂ for at least a century because new carbon debt continuously exceeds NPP. Assuming biofuels are carbon neutral may worsen irreversible impacts of climate change before benefits accrue⁴⁸. Because of this difficulty, there is a moderate reputational risk in case the benefits of this offset are overstated. Previous REDD projects have come under fire for failing to adequately ensure meaningful emissions reductions.⁴⁹

3.2.2. Geological

Geologic carbon sequestration,⁵⁰ also known as carbon capture storage (CCS), is a method of securing carbon dioxide (CO₂) in deep geologic formations to prevent its release to the

⁴⁶ IPCC, 2014: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.

⁴⁷ Carbon Offset Guidance - Second Nature, 2016

⁴⁸ John D Sterman et al. “Does replacing coal with wood lower CO₂ emissions? Dynamic lifecycle analysis of wood bioenergy,” 2018 Environ. Res. Lett. 13 015007 available at <http://iopscience.iop.org/article/10.1088/1748-9326/aaa512/meta>

⁴⁹ Greenpeace, Carbon Scam: Noel Kempff Climate Action Project and the Push for Sub-national Forest Offsets, (Amsterdam: Greenpeace International, 2009)

⁵⁰ “The Concept of Geologic Carbon Sequestration.” Accessed May 17, 2018. <https://pubs.usgs.gov/fs/2010/3122/pdf/FS2010-3122.pdf>.

atmosphere and contribution to global warming as a greenhouse gas. Figure 8 illustrates some of the major concepts associated with geologic carbon sequestration.



Figure 8: Illustration of the Geologic Carbon Sequestration methods and applications

Carbon dioxide can be captured from stationary sources, such as power plants and other large industrial facilities, compressed to a fluid state, and injected deep underground into permeable and porous geologic strata in which it should remain isolated for long periods of time. This process reduces or eliminates the emission of CO₂ into the atmosphere. The geologic formation in which the gas is stored must be overlain by another layer of impermeable rock to seal in the injected CO₂. In figure 8, injection wells are depicted as columns of brown “bubbles” with arrows pointed downward into the earth. Brown bubbles in the storage formation represent geologic storage of CO₂. The technology for geologic sequestration of CO₂ is still being developed, and only a few industrial-sized carbon sequestration projects are operating worldwide. Several are associated with offshore natural gas production.

In 2013, the U.S. Geological Survey (USGS) completed an evaluation⁵¹ of the technically accessible storage resource for CO₂ for 36 sedimentary basins in the onshore areas and State waters of the United States. It is an estimate of the geologic storage resource that may be available for CO₂ injection/storage and is based on current geologic and hydrologic knowledge of the subsurface and current engineering practices. The study identified approximately 3,000 metric gigatons (Gt) of subsurface CO₂ storage capacity that is technically accessible below

⁵¹ "FactSheet_2col v 3.5.1 - USGS Publications Warehouse." Accessed May 17, 2018. <https://pubs.usgs.gov/fs/2013/3020/pdf/FS2013-3020.pdf>.

onshore areas and State waters. Figure 9 summarizes how this CO₂ storage capacity is distributed between all basins. According to this study, the area of the assessment with the most storage potential for carbon dioxide is the Coastal Plains region, which includes coastal basins from Texas to Georgia. That region accounts for 1,900 metric gigatons, or 65%, of the storage potential. Other areas with significant storage capacity include Alaska and the Rocky Mountains-Northern Great Plains.

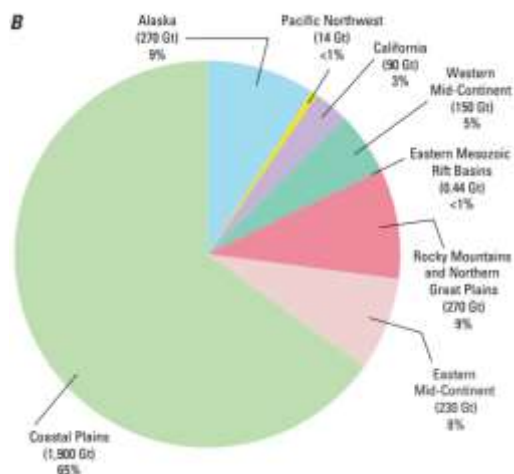


Figure 9: CO₂ storage capacity distribution between basins

Although there is a lot of potential for geological carbon sequestration in the U.S, numerous sources⁵² outline the risks posed by geological sequestration of captured carbon dioxide. The main categories of risks of harm are as follows:

- *Harm to human health:* Escape to the surface of the sequestered CO₂ could harm the general public or injection plant employees;
- *Geological hazards:* Changes in subsurface pressure due to CO₂ injection could lead to a seismic event and ultimately cause the sequestered carbon dioxide to escape and adversely impact climate change;
- *Ecological harms:* The sequestered CO₂ or the pressure front might force brine into fresh water formations, thereby adversely impacting drinking water;
- *Harm to property:* Migration of the sequestered CO₂, or the pressure front, could cause property damage to mineral reserves and/or oil and gas reservoirs, diminution of value or business interruption of neighboring properties if remediation is required, or restrictions to land use activities;

These risks highlight how difficult it is to prove permanence and co-benefits from this type of offset. Besides, these types of projects might not be additional or real. In addition to the risks mentioned above, often times the business plans of these projects include selling the CO₂ to the oil industry to inject it around producing wells in order to increase production through enhanced oil recovery technology (EOR), as illustrated in Figure 8. Although this approach benefits the

⁵² "Risks of Geological Sequestration - Harvard Environmental Law." Accessed May 17, 2018. <http://environment.law.harvard.edu/wp-content/uploads/2015/08/appendix-risks-geological-sequestration.pdf>.

economics of the offset project, it increases the production of fossil fuels which ultimately can increase emissions.⁵³ Moreover, although it is possible to verify the amount of CO₂ captured, it would be necessary to do it over the whole pathway the CO₂ passes through to account for potential escapes, increasing the project cost. Another potential impact of selling the CO₂ is the risk of double counting the avoided emissions by the buyer, which can make this type of offset hard to enforce.

3.3. Energy Efficiency

Energy efficiency projects reduce carbon production through reducing the demand for energy - if there is generally less energy being consumed, there will be less carbon produced. The general concept is to invest in improvements that reduce the amount of energy used while maintaining the same level of productivity.

There are many examples of energy efficiency projects, most of which translate well to the residential environment. Projects such as replacing light bulbs with energy efficient LED light bulbs, updating outdated HVAC systems, or using a more fuel-efficient car are all good examples of this type of projects. Figure 10 also provides a few more examples of energy efficiency improvements for buildings.

⁵³ "Growth in US oil production linked to development of CO₂ capture." Accessed May 17, 2018. <http://hub.globalccsinstitute.com/insights/growth-us-oil-production-linked-development-co2-capture>.

The California Energy Commission approved a set of energy efficient building standards for new homes and commercial buildings. Here are requirements and recommendations:

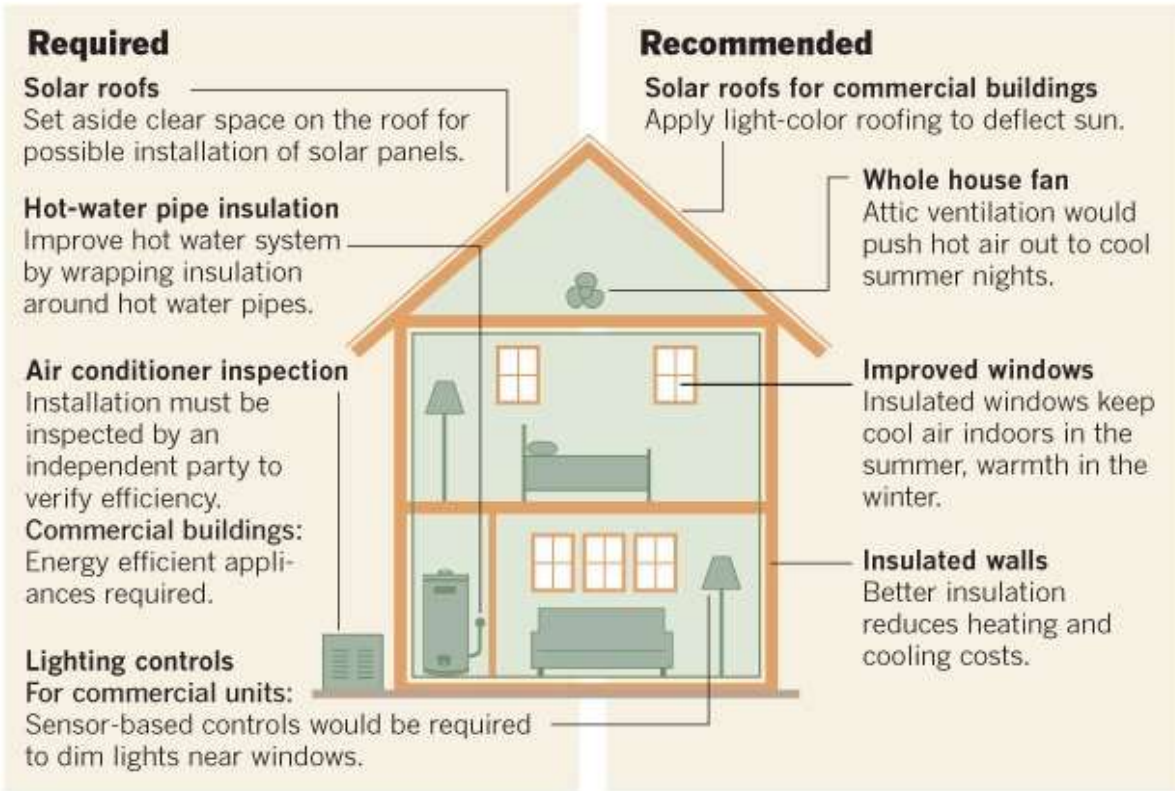


Figure 10: Sample of residential energy efficiency improvements⁵⁴

Nevertheless, it is important to clarify the difference between energy efficiency projects that result in direct emissions reductions from the ones that generate offsets. In order to qualify as a carbon offset, the CO₂-equivalent emission reductions associated with a project must be considered additional. There are many tests for additionality, but essentially additionality means that the emission reductions must be above and beyond those that might be expected under a “business-as-usual” approach. One common approach to determining additionality relies on financial additionality, which depends upon whether the project would not have occurred but for the sale of the carbon offsets it generates – if it would have happened anyway, then the project is not additional under this financial test. Organizations who invest in these “additional” improvements at a large scale, count the reduction in emissions as an offset to their own emissions.⁵⁵

In terms of advantages, the most inherent one is that energy efficiency projects directly save the consumer money - using less energy translates into a savings on energy spending. This gives energy efficiency projects a boost when balancing the stakeholder interests involved in developing an offset project.

⁵⁴ "Energy Commission poised to boost building energy standards - LATimes." (2012) Accessed May 17, 2018. <http://articles.latimes.com/2012/may/30/business/la-fi-mo-commission-energy-standards-20120530>.

⁵⁵ "Financing Energy Efficiency-Based Carbon Offset Projects at Duke University." Accessed May 17, 2018. <https://efc.sog.unc.edu/sites/www.efc.sog.unc.edu/files/Financing%20Energy%20Efficiency%20Offsets.pdf>.

However, the inherent money savings can backfire. It is possible that consumers, once they realize they are paying less for energy, will respond by consuming more energy. This can make both the verification of actual savings and the offset validity a little difficult to prove because this possible rebound effect can be a form of leakage. There is also a risk of indirect rebound effect if the savings are used to increase consumption of other sources of carbon emissions such as car fuels.⁵⁶ In sum, energy efficiency offset projects can be labor intensive when it comes to monitoring.⁵⁷

3.4. Methane combustion

While most offset methods concentrate on CO₂ emissions directly, there are other harmful gases that contribute to global warming, such as methane (CH₄). Roughly 10% of all GHG emissions in the US consist of methane.⁵⁸ Methane collection (and combustion) is a common technique for landfill and agricultural firms to decrease their CO₂ footprint. Methane gas only lasts about a decade on average in the atmosphere, but it absorbs much more energy - the EPA estimates methane's global warming potential (GWP) is 28-36 times that of CO₂ over 100 years (GWP100). Since methane has a shorter lifetime than CO₂, the GWP in 20 years is 84-87 times that of CO₂.⁵⁹ To combat this, it's possible to convert methane into CO₂ through combustion. This process has the effect of decreasing the GWP of one methane molecule by greater than 95% through turning it into a CO₂ molecule. This offset is even more beneficial if that combustion is used to create heat and/or power, instead of gas, oil or coal.

Methane capture techniques are typically implemented at landfills and agricultural areas, where waste is common and resulting methane release is prevalent. The burning of methane not only results in less GHG emissions but also releases energy, which can be processed and used as a renewable energy source. Figure 11 illustrates that process.

An example of this project is a partnership between University of New Hampshire (UNH) with Waste Management of New Hampshire. UNH launched a pipeline to transport enriched and purified gas from Waste Management's landfill in Rochester to its campus. The methane from landfill gas replaced commercial natural gas as the primary fuel in UNH's cogeneration plant, which provides electricity and heat for the main campus building. When fully operational, the project will provide up to 85% of the campus energy.⁶⁰

⁵⁶ Peter O'Connor. "What is the Rebound Effect? — Energy Efficiency, Part 2." Accessed May 17, 2018. <https://blog.ucsusa.org/peter-oconnor/energy-efficiency-what-is-the-rebound-effect-946>.

⁵⁷ Carbon Offset Guidance - Second Nature, 2016

⁵⁸ "Overview of Greenhouse Gases - EPA - 2016" Accessed May 17, 2018. <https://www.epa.gov/ghgemissions/overview-greenhouse-gases>.

⁵⁹ "Understanding Global Warming Potentials | Greenhouse Gas Emissions - EPA." Accessed May 17, 2018. <https://www.epa.gov/ghgemissions/understanding-global-warming-potentials>.

⁶⁰ "Cogeneration & EcoLine (Landfill Gas) | Sustainability Institute - UNH" Accessed May 17, 2018. <https://sustainableunh.unh.edu/ecoline>.

Methane capture projects are relatively simple to prove as permanent - once the methane is burned, it is converted to CO₂, and the process is complete. Lots of rating agencies validate methane capture projects, making these projects relatively cheap to implement and validate. The residual use of the energy is certainly a co-benefit, but other socioeconomic co-benefits are hard to incorporate. This is also an active area of regulation,⁶¹ making risks of a changing regulatory landscape somewhat high.

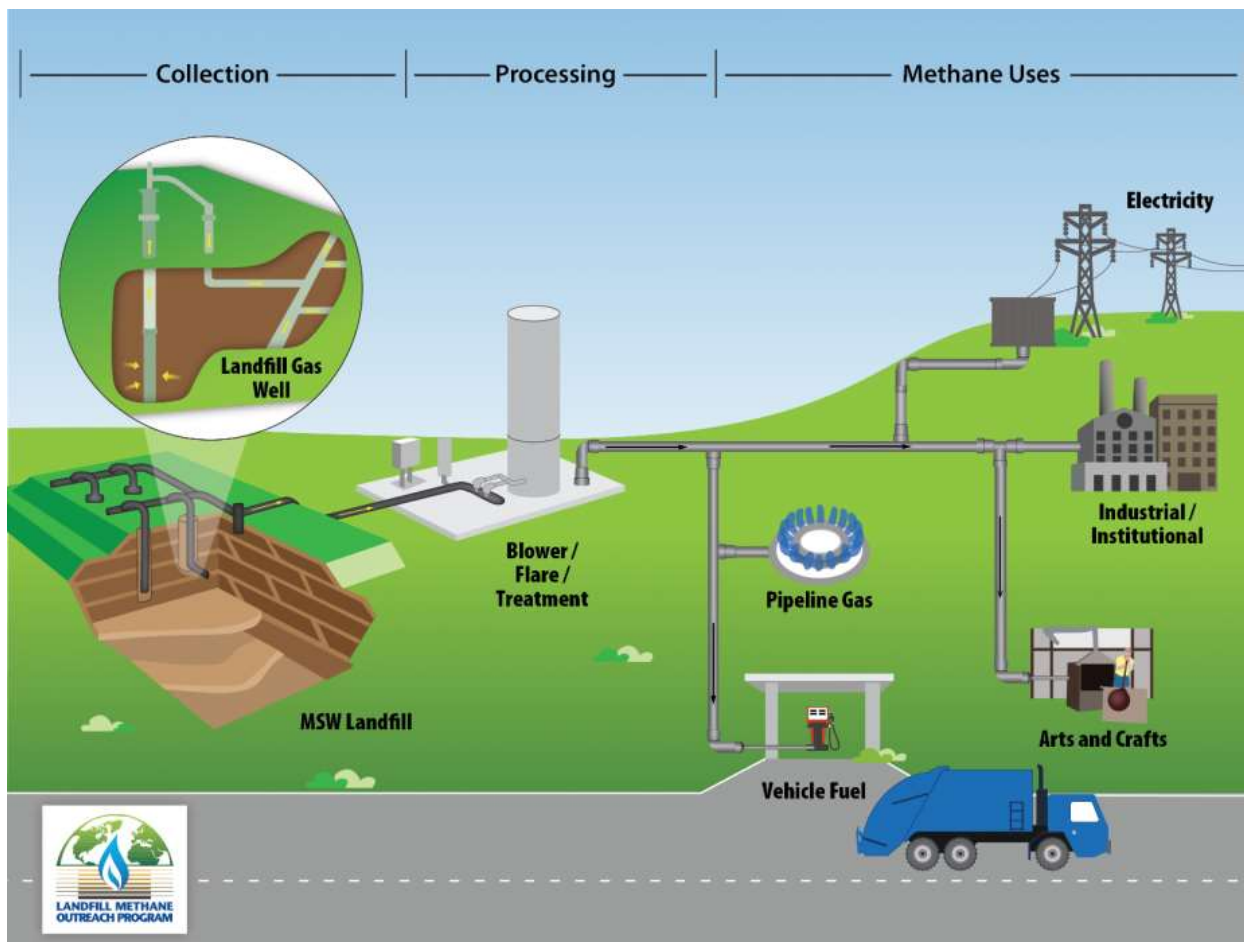


Figure 11: Illustration of methane capture and possible resulting energy uses⁶²

3.5. Industrial gas mitigation

Industrial gases are a special class of gases used solely in industrial settings. Examples of these gases include hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF₆), and nitrous oxide (N₂O). All of these gases have global warming potentials significantly larger than

⁶¹ "State Methane Policies - National Conference of State Legislatures." Accessed May 17, 2018. <http://www.ncsl.org/research/environment-and-natural-resources/state-methane-policies.aspx>.

⁶² "Basic Information about Landfill Gas | Landfill Methane Outreach Program - EPA." Accessed May 17, 2018. <https://www.epa.gov/lmop/basic-information-about-landfill-gas>.

CO₂ in a 100 year timeframe: up to 14,800x for HFCs; 10,300x for PFCs; 22,800x for SF₆; and 298x for NO₂.⁶³

These gases are found in a variety of commercially produced materials. HFCs can be found in refrigeration and air-conditioning equipment, as well as some fire extinguishers. PFCs are found in some electronics as well as cosmetics, while SF₆ is used as an insulating gas. These “F-gases” have been subject to recent regulation on an international scale - the EU has aimed to cut their F-gas emissions by two-thirds by 2030, while the Kigali Amendment to the Montreal Protocol added HFCs to the list of controlled substances in an effort to save 80 gigatons of CO₂ equivalent by 2050.⁶⁴

Industrial gas mitigation offsets have a distinct advantage in the cost department. The implementation of a capture device is usually cheap, and a fairly simple implementation relative to other offsets.⁶⁵

However, industrial gas mitigation has some complicating factors. Some argue that crediting these projects with carbon offsets may reduce the incentive to stop using the gases in the first place. If a company can benefit from the production of these gases in any way, there may not be as much of an impetus to prohibit them. Additionally, the scope of these projects are typically narrow - there usually are not many co-benefits associated with their implementation.⁶⁶ Due to these previous concerns, few rating agencies certify this type of offset. Consequently, enforceability is hard to satisfy and there is regulation and reputational risk associated with this offset.

3.6. Carbon permit retirement

One simple method to purchase carbon offsets is simply to purchase carbon permits from existing cap-and-trade systems in regional electricity markets and then retire these permits. This effectively lowers the cap in that market beyond the business-as-usual scenario resulting in a reduction in GHGs that can be counted as an offset. The largest risk with this strategy is counting if the cap-and-trade market encompasses the permit purchaser. To see how this might be, imagine if the City of Boston purchased carbon permits from RGGI. This would result in a real reduction in GHG and could potentially be counted as an offset for the city. However, Boston purchases its electricity from the same electricity system that is regulated by RGGI. Thus, by reducing the cap, the electricity sold to Boston is less carbon intensive than it was previously which appears to reduce the Boston’s Scope 2 emissions. This would be double counting, both offsetting emissions and reducing Scope 2 emissions from the same single action. To address this concern, Cambridge, which has been evaluating offsets as a potential tool to meet their

⁶³ "2.10.2 Direct Global Warming Potentials - AR4 WGI Chapter 2 - IPCC Fourth Assessment Report: Climate Change 2007." Accessed May 17, 2018. https://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch2s2-10-2.html.

⁶⁴ "Fluorinated greenhouse gases | European Commission - Climate Action" Accessed May 17, 2018. https://ec.europa.eu/clima/policies/f-gas_en.

⁶⁵ Carbon Offset Guidance - Second Nature, 2016

⁶⁶ Carbon Offset Guidance - Second Nature, 2016

emission targets, has concluded that they will not allow RGGI permits to serve as offsets for this reason.⁶⁷

3.7. PAVER+ and risks comparison

In sum, the different types of offsets and RECs available face different levels of difficulty to satisfy the PAVER+ criteria (which stands for Permanent, Additional, Verifiable, Enforceable, Real and Co-benefits). The table below summarizes a qualitative assessment of the difficulty level (easy, moderate or hard) for selected types of offsets based on literature research and case studies. The assessments here reflect our understanding of the market today, and should be updated periodically as technology and policy advance.

Table 2: Qualitative assessment of difficulty level to satisfy PAVER+ for selected types of offsets

Difficulty level	Type							
	Renewable Energy (offsets)	Renewable Energy (RECs)	Biological Carbon Sequestration	Geological Carbon Sequestration	Energy Efficiency	Methane combustion	Industrial gas mitigation	Carbon permit retirement
Permanent	Easy	Easy	Hard	Hard	Easy	Easy	Easy	Easy
Additional	Moderate	Easy (not required)	Hard	Hard	Moderate	Moderate	Moderate	Moderate
Verifiable	Easy	Easy	Moderate	Moderate	Moderate	Easy	Moderate	Moderate
Enforceable	Easy	Easy	Moderate	Hard	Easy	Moderate	Hard	Moderate
Real	Easy	Easy	Moderate	Hard	Moderate	Easy	Moderate	Moderate
Co-benefits	Moderate	Moderate	Easy	Hard	Easy	Moderate	Hard	Moderate

According to this assessment, in general Renewable energy (offsets and RECs) and Energy efficiency present lower levels of risk when compared to other types of offsets. On the other hand, geological sequestration has the highest level of risk among the selected types. Although this framework is able to offer a comparison between different types of offsets, no distinction was made on the relevance each criteria should have given that it might vary depending on the goal of the entity who is selecting the type of offset.

⁶⁷ Details on Cambridge's carbon offset initiative are discussed in more detail in Section 6.2.

Additionally, the different types of offsets pose different levels of implementation risks. These risks can be described as:

- **Market / financial:** Risk of market instabilities, non-favorable net-present value (NPV) of the initiative;
- **Technology / implementation:** Risk of technology not resulting in expected emissions reductions or too complex to implement correctly;
- **Policy / regulation:** Risk of not complying with federal and state policies and regulations requirements;
- **Supply chain:** Risk of not having enough suppliers or sufficient offers;
- **Reputational:** Risk of harming entity's brand and reputation due to questionable results on emission reductions

The table below summarizes a qualitative assessment of the risk level (high, medium or low) for selected types of offsets based on literature review and case study analysis.

Table 3: Qualitative assessment of risk level for selected types of offsets

Risk	Type							
	Renewable Energy (offsets)	Renewable Energy (RECs)	Biological Carbon Sequestration	Geological Carbon Sequestration	Energy Efficiency	Methane combustion	Industrial gas mitigation	Carbon permit retirement
Market / Financial	Medium	Low	Low	High	Low	Medium	Low	Low
Tech / Implementation	Medium	Low	Low	High	Medium	Low	Low	Medium
Policy / Regulation	Medium	Medium	Low	Medium	Low	High	High	Medium
Supply Chain	Low	Low	Low	Medium	Low	Medium	Low	Low
Reputational	Low	Low	Medium	High	Low	Medium	High	Medium

4. The Market for Offsets and RECs

There are many active players in the market for offsets and RECs. Offset or REC projects often start with developers who work onsite to bring the project to fruition. Third party reviewers and rating agencies (or in the case of RECs, regulatory entities) then evaluate these projects to certify

the credibility of the crediting mechanism. Brokers and retailers or registries then commonly serve as the intermediary platform, aggregating offsets or RECs for sale and tracking the unique identification number associated with each to insure that ownership remains clear and transparent. Finally, the purchaser (end buyer), who acquires the offset either directly from the developer or through an intermediary retailer, holds or uses and retires the credit. Figure 12 illustrates the offset cycle and the interaction between these different players in the market.

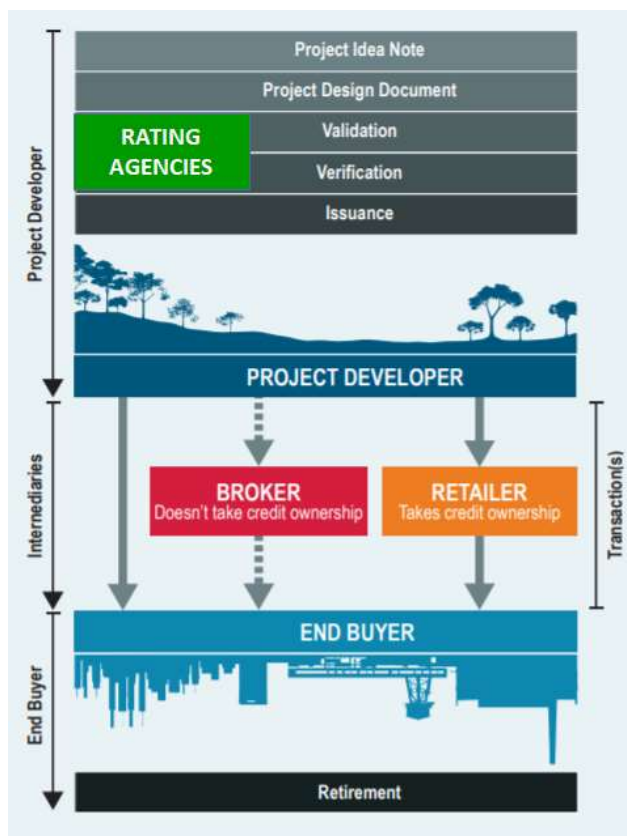


Figure 12: The Offset Cycle, from project development to retirement⁶⁸

This is a dynamic market with new entities entering frequently and detailing all the related service providers is beyond the scope of this report. However, the role of rating agencies is crucial to ensuring that offsets are credible. Therefore, we explore the differences between evaluation methodologies employed by these institutions in this section. There are multiple standards for different carbon offset projects. The table 4 below lists some of them.

⁶⁸ "State of the Voluntary Carbon Markets 2017 - Forest Trends." Accessed May 17, 2018. https://www.forest-trends.org/wp-content/uploads/2017/09/doc_5591.pdf.

Table 4: Overview of Carbon Offset Standards^{69,70,71,72}

Program	Description
<p>The following two mechanisms are those under the Kyoto Protocol. They are used by countries and private buyers that are covered under an emissions trading scheme or that do them in a voluntary way.</p>	
<p>Clean Development Mechanism (CDM)</p>	<p>Offset projects located in developing countries that have ratified the Kyoto Protocol.</p>
<p>Joint Implementation (JI) Track 1</p>	<p>“JI can be implemented under Track 1, under which host countries are responsible for most aspects of the project cycle (including registration and issuance). Under Track 2, which is overseen by the UNFCCC, requirements and procedures are similar to those of the CDM. 97 percent of all JI offsets have been issued under Track 1”⁷³.</p>
<p>The following are voluntary programs that generate offsets that are used in the voluntary market:</p>	
<p>Climate Action Reserve (CAR)⁷⁴</p>	<p>The premier carbon offset registry for the North American carbon market.</p>
<p>Verified Carbon Standard (VCS)⁷⁵</p>	<p>This program allows projects to turn their greenhouse gas emissions reductions into tradable carbon credits. It is the world’s largest voluntary carbon credit market.</p>
<p>VCS Jurisdictional and Nested REDD+ (JNR) Framework.</p>	<p>It “provides guidance to governments to support the design, implementation and integration of projects and programs that conserve and enhance forests at national and sub-national levels and leverage carbon finance”⁷⁶</p>
<p>Gold Standard (GS) and Global Standard for the Global Goals</p>	<p>“Project-based, voluntary offset mechanism that can be used as add-on certification to CDM and JI projects or for voluntary projects.”⁷⁷</p>

⁶⁹ World Bank. 2015. *Overview of carbon offset programs : similarities and differences*. Partnership for Market Readiness technical papers ; no. 6. Washington, DC : World Bank Group. <http://documents.worldbank.org/curated/en/891711468309365201/Overview-of-carbon-offset-programs-similarities-and-differences> (hereafter “World Bank 2015”)

⁷⁰ WWF, SEI, Tricorona, 2008

⁷¹ “carbonfootprint.com - Carbon Offset Standards.” Accessed May 17, 2018. <https://www.carbonfootprint.com/offsetstandards.html>.

⁷² “PMR Technical Note 6: Overview of Carbon Offset Programs.” Accessed May 17, 2018. https://www.thepmr.org/system/files/documents/PMR%20Technical%20Note%206_Offsets_0.pdf. (hereafter “PMR Technical Note 6”)

⁷³ World Bank 2015

⁷⁴ “About Us : Climate Action Reserve.” Accessed May 17, 2018. <http://www.climateactionreserve.org/about-us/>.

⁷⁵ “Who We Are - Verra.” Accessed May 17, 2018. <http://verra.org/about-verra/who-we-are/>. (hereafter “Verra - Who We Are”)

⁷⁶ Ibid.

⁷⁷ PMR Technical Note 6

	The most recent version helps certify the attainment of SDGs. ⁷⁸
American Carbon Registry Standard (ACRS)	“In both the voluntary carbon market and California's regulated carbon market, ACR oversees the registration and verification of carbon offset projects and issues offsets on a registry system. As an approved Offset Project Registry (OPR) ⁷⁹ for the California Cap-and-Trade program, ACR works with the state regulatory agency, the Air Resources Board (ARB), to oversee the listing and verification of carbon offset projects.” ⁸⁰
Climate Community & Biodiversity Standard (CCBS) ⁸¹	The CCB Standards serve as criteria for evaluating the co-benefits generated for the community and biodiversity by land-based carbon mitigation projects. “Verification to the CCB Standards ensures that projects are improving livelihoods, creating employment, protecting traditional cultures and endangered species, and helping secure tenure to lands and resources, as well as making a key contribution to combating climate change.” ⁸²
Sustainable Development Verified Impact Standard (SD VISta)	It provides a “flexible framework for assessing and reporting on the sustainable development benefits and Sustainable Development Goal contributions of project-based activities, helping unlock new sources of finance to support and scale up high-impact efforts.” ⁸³
International Green-e Climate	“Green-e Climate certifies GHG emissions reductions (offsets) sold in the market—not the projects that generate them. Green-e Climate certified emission reductions must be sourced from projects validated and registered with an endorsed project standard and certification program. The aim is to provide buyers with assurance that the project is high-quality, that reductions are not double counted, and that the buyer receives all information needed when purchasing an offset.”
International Organization for Standardization - ISO 14064-2	These are voluntary GHG accounting standards. The protocol establishes definitions and procedures to account for GHG reductions in an offset program.
Plan Vivo standard	“Plan Vivo certifies forestry offset programs, ensuring that livelihood needs are considered and built into project design and that local income sources are diversified to reduce poverty and tackle the root causes of deforestation and land degradation. The Plan Vivo standard is a label

⁷⁸ "The Gold Standard." Accessed May 17, 2018. <https://www.goldstandard.org/>.

⁷⁹ "California Offset Program — American Carbon Registry." Accessed May 17, 2018. <https://americancarbonregistry.org/california-offsets/california-offset-program>.

⁸⁰ "What We Do — American Carbon Registry." Accessed May 17, 2018. <https://americancarbonregistry.org/how-it-works/what-we-do>.

⁸¹ "CCB Standards | CCBA - The Climate, Community & Biodiversity Alliance." Accessed May 17, 2018. <http://www.climate-standards.org/ccb-standards/>.

⁸² Verra - Who We Are

⁸³ Ibid.

	that is applied to offsets generated from an offset program.” ⁸⁴
The Voluntary Emissions Reduction VER+ Standard	Developed by TÜV SÜD (a German based verification company). “Projects are verified by a third party auditor which must be CDM/JI accredited. All VER+ offset credits must be registered in TÜV SÜD’s own Blueregistry. This prevents the double selling of credits and aids transparency.” ⁸⁵
Voluntary Offset Standard - VOS	“VOS is a carbon offset screen that accepts other standards and methodologies using certain screening criteria. It currently accepts Gold Standards VER projects and projects that employ CDM procedures but which are implemented in countries that have not ratified the Kyoto Protocol and are therefore not eligible for Clean Development Mechanism” ⁸⁶
The GHG Protocol for Project Accounting ⁸⁷	“The Project Protocol provides specific principles, concepts, and methods for quantifying and reporting GHG reductions—i.e., the decreases in GHG emissions, or increases in removals and/or storage—from climate change mitigation projects (GHG projects).” ⁸⁸ In addition, there is the The Land Use, Land-Use Change, and Forestry (LULUCF) Guidance and the the Guidelines for Grid-Connected Electricity Projects

According to a market survey⁸⁹ (see figure 13), in 2016, 99% of offsets in the voluntary carbon markets were certified by a third-party standard. Respondents reported using thirteen different standards. VCS was the most common being responsible for certifying almost 33 MtCO₂e. Of those, 7.7 MtCO₂e were also certified by CCB, which focuses on social and environmental co-benefits of land-based projects, but does not issue emissions reduction credits. Other common standards were the Gold Standard (17%), and CDM (8%), Climate Action Reserve (8%), and American Carbon Registry (3%).

In addition, according to this same survey, the average offset price varied greatly among different standards. The average price of offsets associated with the five most common standards, which collectively made up 91% of the transaction volume, ranged between \$1.6/tCO₂e (CDM) and \$4.6/tCO₂e (Gold Standard).

⁸⁴ World Bank 2015

⁸⁵ “The VER+ Standard | Shaping Sustainable Markets.” Accessed May 17, 2018.

<https://shapingsustainablemarkets.iied.org/ver-standard>.

⁸⁶ “Voluntary Offset Standard - Global Greenhouse Warming.” Accessed May 17, 2018. <http://www.global-greenhouse-warming.com/voluntary-offset-standard.html>.

⁸⁷ Boston currently uses the GHG Protocol for Project Accounting.

⁸⁸ “Project Protocol | Greenhouse Gas Protocol - GHG Protocol.” Accessed May 17, 2018.

<http://ghgprotocol.org/standards/project-protocol>.

⁸⁹ “State of the Voluntary Carbon Markets 2017 - Forest Trends.” Accessed May 17, 2018. https://www.forest-trends.org/wp-content/uploads/2017/09/doc_5591.pdf.

Less common standards tended to focus on a particular country, region, or project type. Plan Vivo, for instance, which certified 0.6% of offsets traded in 2016, only recognizes community land use and forestry projects.



Figure 13: Voluntary Market offset volume, value and price per Standard, 2016^{90 91}

It should be noted that there is a potential conflict of interest related to the approval process of projects and their certification. Usually, auditors are chosen and paid by a project’s developer and moreover there are fundamental differences among standards as to how projects are reviewed and approved. For this reason, the City of Boston needs to do a careful assessment when choosing the standards and it is important to look for the highest quality. Boston should avoid settings where auditors are paid by the project developers in order to guarantee the independence and transparency of the process and results.

⁹⁰ Based on 827 transactions representing 57.3 MtCO_{2e} in 2016

⁹¹ "State of the Voluntary Carbon Markets 2017 - Forest Trends." Accessed May 17, 2018. https://www.forest-trends.org/wp-content/uploads/2017/09/doc_5591.pdf.

5. Selecting the best Offset or REC for the circumstances

Taking into account all the different types of offsets available, as well as the various market players available and their services, it's important to develop a strategy for selecting which offset is the best for the circumstance. In our research, we uncovered numerous offsets that were significantly successful, but all of them arose from different economic, political, and geographic considerations. These considerations undeniably influenced each organization's decision making, and helped drive the point that no one offset is perfect for every organization. The City of Boston will need to decide both what's important and what's feasible in their prospective offset projects, and they will need to utilize a few key strategies to aid their decision making process.

In this section, we discuss a few themes we came across when examining how organizations weighed which offset was best for their circumstances. In support of each theme, we will highlight a case study we found illustrated the motivation well.

5.1. Leveraging local resources

Most notably, we found that organizations showed a strong tendency to select offsets that leveraged their local resources whenever possible. Whether it be the community's natural resources, the local political motivations, or simply supporting local organizations, these projects made local impact a priority.

Case Example 1: Duke University Carbon Offsets Initiative⁹²

Context:

Lloyd Ray Farms used a methane combustion "waste-to-energy" project. It is the result of collaborative efforts between multiple actors including Duke Pratt School of Engineering, Nicholas Institute for Environmental Policy Solutions, Google, Duke Energy, Cavanaugh & Associates, NC Soil and Water Conservation, and Natural Resource Conservation Services.

Approach:

- It is an innovative waste-to-energy project that collects methane generated by the decomposition of hog waste and burns it to generate electricity.
- The system generates carbon offsets for Duke University. In addition, the RECs generated by the project are contracted to Duke Energy for their project partnership.
- The electricity generated is used onsite by the swine-farm facilities, the system itself, or is fed back into the grid.

Outcome:

⁹² "Carbon Offsets Initiative | Sustainability - Sustainable Duke." Accessed May 17, 2018. <https://sustainability.duke.edu/offsets>.

- In addition to the reduction of GHG emissions, there are co-benefits including educational, social, and environmental.
- Two additional programs led by the initiative include home Energy Efficiency Training Program in North Carolina and Urban Tree Planting with Carbon Offset Protocol.

Case Example 2: California Offset Purchase Program

Context:

California regulations require the state to reach 1990 levels of GHG emissions by 2020, and 40% below that by 2030.

Approach:

- Regulators set up a cap and trade program between forest owners (including those in CA) and CA corporations
- Regulators went to forest owners with recommendations on how to change their forest management to increase CO₂ intake
- Methods were approved and validated by scientific panels and professional foresters
- Upon making these improvements, forest owners receive a credit for each ton of CO₂ saved
- Forest owners then sell these credits to corporations in CA to help meet emission reductions

Outcome:

- Stanford researchers validated the additionality of the program: 64% of the forest owner participants were engaged in active logging during the time of the program.⁹³ These forest owners had to change their practice to accommodate the project requirements, which Stanford researchers point to as an additional-satisfying outcome.
- The program was designed with permanence in mind - requirements include “100 years of monitoring projects after their last credit received.”
- Total amount of emissions allowed to be offset is capped at 8%, while the current pool of approved offsets is only 2% of emissions reduction target.⁹⁴ This keeps pressure on polluters to directly reduce their pollution rather than rely solely on offsets.
- 20% of offset credits generated are held in reserve.⁹⁵ This is estimated to combat any effects of “reversal risk” or “leakage.”
 - Note that this a direct measure taken by the project owners to address typical weaknesses of biological carbon sequestration. We found this to be a valuable

⁹³ "Carbon offsets have wide-ranging environmental benefits | Stanford" Accessed May 17, 2018. <https://news.stanford.edu/2017/08/14/carbon-offsets-wide-ranging-environmental-benefits/>.

⁹⁴ "Carbon Offsets Really Do Help Lower Emissions - Scientific American." Accessed May 17, 2018. <https://www.scientificamerican.com/article/carbon-offsets-really-do-help-lower-emissions/>.

⁹⁵ Anderson CM, Field CB, Mach KJ (2017) Forest offsets partner climate- change mitigation with conservation. *Front Ecol Environ* 15:359–365 (hereafter “Anderson, Field, Mach 2017”)

example of how innovative project design can overcome the standard issues with an offset project.

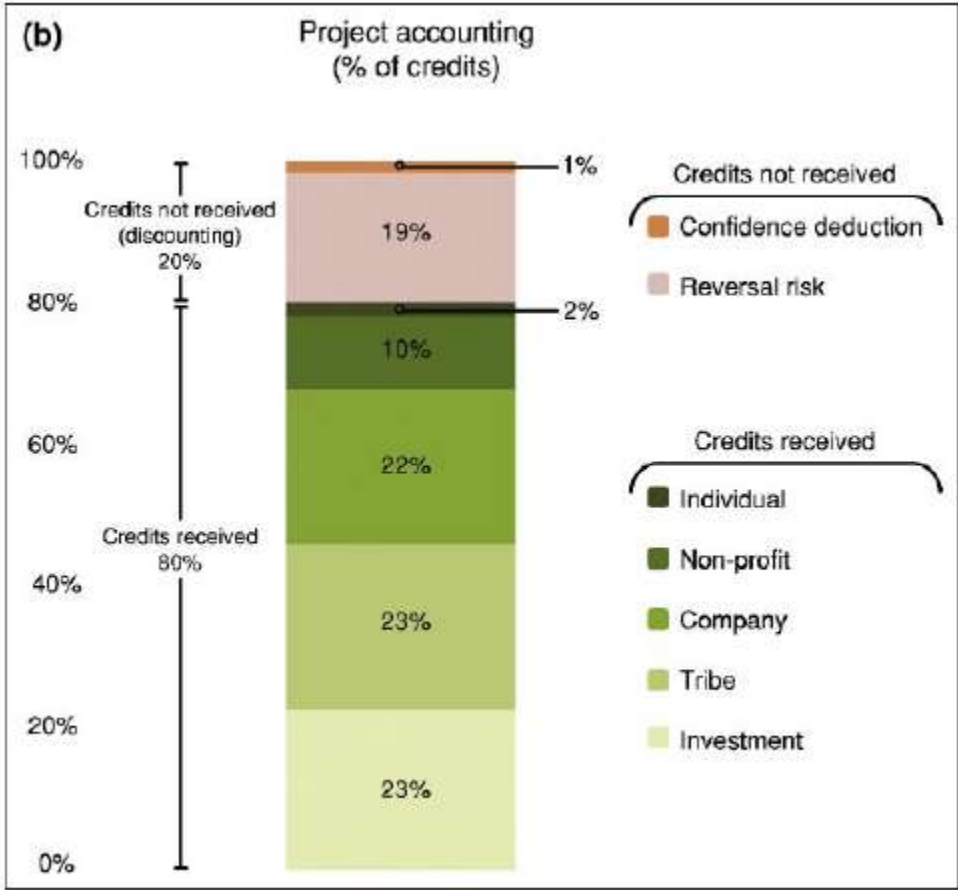


Figure 14: California Offset Purchase Program credit accounting breakdown⁹⁶
 20% of offset credits produced are held in reserve to account for possible “reversal risk” and “confidence deduction” (i.e. “leakage”)

5.2. Optimizing for institutional objectives

All organizations have broad objectives that drive their day to day decisions. Whether it is at a university that’s constantly striving to improve the education of its students, or a city looking to strengthen community bonds, organizations are looking for synergies between their long term goals and short term decisions. We have found that the offset project decision falls into this framework as well - the following are a few examples of how an institution’s goals affected their offset project selection.

Case Example: Palo Alto invests in forestry project in Sister City Oaxaca, Mexico

⁹⁶ Anderson, Field, Mach 2017

Context:

- Palo Alto, CA has been providing carbon neutral electricity since 2013, but has remaining goals to become carbon neutral across all city operations.
- Palo Alto is pushing to neutralize greenhouse gas emissions from natural gas usage within the city through energy efficiency and electrification of natural gas appliances. While this is a longer term direct emissions related project, they decided to use offsets as a short-term strategy to neutralize their impact as soon as possible. The city has been investing in “high quality”, “locally certified” carbon offsets since July 2017.⁹⁷

Approach:

- City officials worked with groups in both California and Mexico to certify forestry offsets in Oaxaca under the Climate Action Reserve standards.
- “Joint effort between forest owners, civil society organizations, and the City of Palo Alto”

Outcome:

- Palo Alto will purchase 17,000 carbon offsets for \$136,000; neutralize 10% of city’s natural gas emissions
- “This is an excellent example of how environmental, social and economic issues can positively intersect when we collaborate with one another”⁹⁸
- Utilized a political partnership (sister city relationship) to put together a mutually beneficial project for both a “developed” and “developing” region

5.3. Balancing stakeholder needs

Throughout our research, we noticed that in almost every carbon offset project there is some political jousting that needs to be accommodated. The organizations implementing these projects are almost always complex, and as such there are various stakeholders (both internal and external) whose opinions need to be considered in choosing the best project. The following projects are nice examples of organizations mapping various stakeholder interests (such as local governments, communities, and utilities) effectively.

Case Example 1: Google adapts its offset project tactics to energy market dynamics and regulations in different locations⁹⁹

⁹⁷ “Palo Alto to Buy “Carbon Offsets” from Sister City - City of Palo Alto.” Accessed May 17, 2018.

<https://www.cityofpaloalto.org/civicax/filebank/documents/62608>.

⁹⁸ “Announcing the First Issuance of Forest Carbon Credits to San Juan Lachao under the Climate Action Reserve’s Mexico Forest Protocol” Accessed May 17, 2018. <http://www.climateactionreserve.org/blog/2017/12/12/announcing-the-first-issuance-of-forest-carbon-credits-to-san-juan-lachao-under-the-climate-action-reserves-mexico-forest-protocol/>.

⁹⁹ “Achieving our 100% Renewable Energy Purchasing Goal and Going Beyond - Google.” Accessed May 17, 2018. <https://static.googleusercontent.com/media/www.google.com/pt-BR//green/pdf/achieving-100-renewable-energy-purchasing-goal.pdf>

Context:

Google was one of the first corporate movers on renewables; it committed to achieving 100% renewable energy purchasing for its operations in 2012 and today is the world's largest purchaser of renewable energy (see figure 15). In 2017 it purchased enough RECs to cover all its operations.

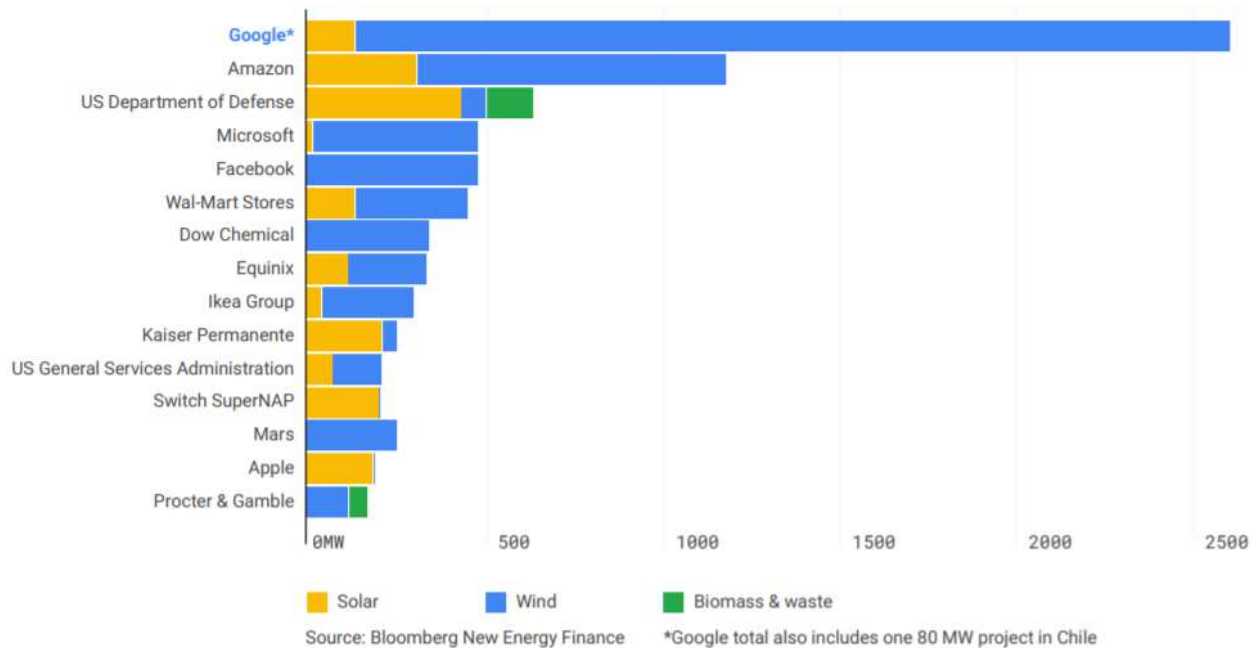


Figure 15: Cumulative corporate renewable energy purchasing in the US, Europe and Mexico, November 2016

Approach:

In order to reach its goal, the company applied three primary tactics to adapt its plan to energy market dynamics and regulations in different locations, which were:

1. **“Direct” renewable purchasing** (deregulated wholesale and retail power markets): sign PPA with a project developer on a grid where they operate a data center, as well as a separate “balancing agreement” with a competitive power market entity that helps deliver the PPA across the grid and that can also “firm and shape” to have constant, 24-7 electricity.
2. **“Offsetting” renewable PPAs (“fixed-floating swaps”)** (regulated retail markets but deregulated wholesale markets): Purchase renewable energy at the wholesale level, retire the associated RECs, and sell the power back into the same grid from which we later draw power at the retail level (see figure 16). Despite all the benefits of fixed-floating swaps, the model also creates unnecessary layers of complexity and dilutes the financial benefits that the company receive as an end user. Because of restrictive retail market structures, they are essentially buying power twice and selling it once—buying once at the competitive wholesale level and again at the regulated retail level, while they also sell at the competitive wholesale level. Since these two prices aren't always correlated, they don't reduce our exposure to market price volatility quite as much. Further, these structures also

require significant resources and expertise to execute, as well as a long-term commitment from the buyer, so they aren't scalable options for many smaller companies that want to purchase renewable power.

3. **Utility renewable energy tariffs** (where there is no auction-based wholesale market): worked with utilities providers to create a new class of rates called a "renewable energy tariff," in which the utility procures renewable energy on our behalf for sale and delivery it to the company.

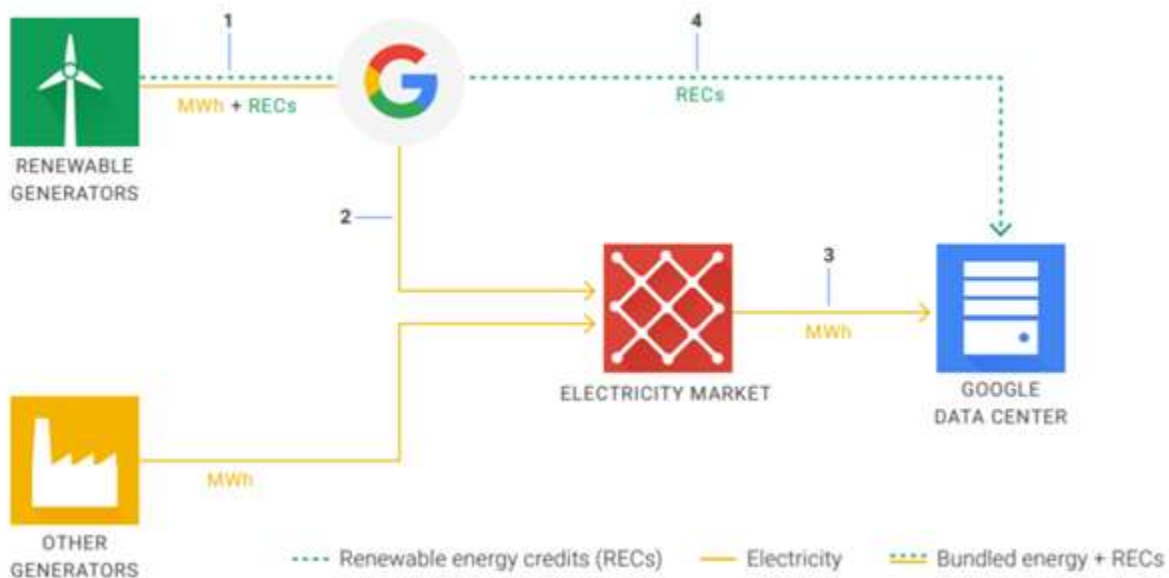


Figure 16: Illustration of the "fixed-floating swaps" tactic

Outcome:

When pursuing any of the first three approaches above, Google was able to either lead or actively collaborate with a utility in the procurement process. This allowed them to apply very high standards for what types of renewable energy projects they count toward the 100% goal. Specifically, they apply three key criteria in selecting projects: additionality, physical energy bundled with its "renewable certification" and proximity.

Case Example 2: Apple and state utilities commission create new regulatory structure¹⁰⁰

Context:

Apple was the first IT company to make a 100% RE commitment for both its own operations and its supply chain. Apple has set near-term goals of 4GW of renewable energy for its supply chain by 2020, 2GW in China specifically.

Approach:

¹⁰⁰ "Apple Environmental Responsibility Report, 2017 Progress Report." Accessed May 17, 2018. https://images.apple.com/environment/pdf/Apple_Environmental_Responsibility_Report_2017.pdf.

Apple worked with NV Energy and the state's utilities commission to create a new regulatory structure called the Nevada Green Rider Program,¹⁰¹ which let big green power buyers like Apple pay extra costs associated with developing renewable power. This cleared the way for Apple to build new renewable energy projects, sell the electricity generated to NV Energy, and then buy it back at retail.

Outcome:

While Apple is playing a leading role in building out green-energy infrastructure, in the end it's a maker of computing hardware, software, and services, not an energy company. That's why it likes to partner with a local utility or independent green power provider which understands the power market and knows how to do things like balancing power loads against supply. Now that the cost of renewable energy is far lower, local utilities, developers, and green-energy companies are willing to take on greater roles and risk in building new energy projects; Apple's main role is often to commit to buying the power for periods up to 20 years. Not only does that commitment help the developers of the green energy projects secure financing, but it also gives Apple low and predictable energy rates for years into the future. The Green Rider program let Apple purchase power from two other Nevada solar farms—the 50-megawatt Boulder II solar array, and the 200-megawatt Techren Solar project, which is expected to come online by the end of 2018.

6. Designing the best Offset and REC program for the circumstances

The PAVER+ framework and the risk level evaluation presented are useful tools to make the selection of the best offset for certain preferences. However, other factors might also impact this decision, such as the intended goal of the offset program, which ultimately may result in different approaches for an offset program.

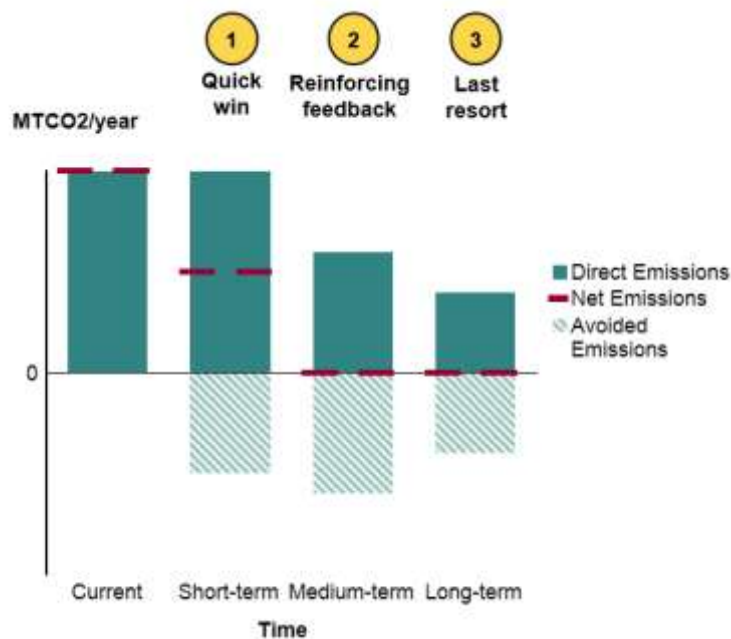
In our research, we found there were three main approaches organizations' used in the temporal design of their offset programs:

1. **Quick win (short-term):** Use avoided emissions from offsets to reduce net emissions faster in the short-term;
2. **Reinforcing feedback (medium-term):** Use avoided emissions from offsets to reduce net emissions in the medium-term and combine it with investments in direct emissions initiatives to reach net zero emissions faster;
3. **Last resort (long-term):** Use offsets to account for residual direct emissions that could not be reduced previously in order to reach net zero emissions in the long-term.

Figure 17 below illustrates the impact each approach could have over time on direct emissions, avoided emissions and net emissions.

¹⁰¹ "Northern NV Green Energy Choice | NV Energy." Accessed May 17, 2018. <https://www.nvenergy.com/account-services/energy-pricing-plans/green-energy>.

One or multiple of these approaches can be selected for designing the offset program depending on the goals of the entity promoting it and the nature of the direct emissions. If the focus is reaching net zero carbon emissions faster, than approaches 1 and 2 are often utilized, while approach 2 is often used as a way to accelerate the direct emissions reductions. In cases where there are no more direct ways for the organization to further reduce emissions, approach 3 is more commonly used as that last resort to reach net zero emissions. Nevertheless, it is important to highlight that the decision between investing in direct emissions reduction projects versus offsets projects has to incorporate the total “value” of each initiative. The “value” analysis should consider not only the monetary savings it would directly generate but also other factors such as the effective amount of direct emissions reduction, avoided emissions, potential co-benefits and



also the risks associated with each project.

Figure 17: Illustrative impact on emissions of the 3 main approaches for offset programs

6.1. Quick win

The “quick win” approach consists of creating offset programs with the goal of counting the avoided emissions from the offsets to reduce the organization’s net emissions faster in the short-term.

Some organizations have utilized this approach, as detailed on the following case studies:

Case Example: MIT/Harvard/Stanford University use RECs to reach carbon neutrality faster

Context:

Harvard University, Stanford and MIT have established various carbon neutrality goals that exceed the regulatory requirements.

Approach:

- These universities have focused on RECs.
- In 2009, Harvard signed long-term, large scale Power Purchase Agreement (PPA) + RECs from a wind project in Maine. The university retired Class I RECs from this project and purchased existing hydro power certificates in Massachusetts.
- MIT joined the Boston Medical Center and Post Office Square Redevelopment Corporation for a 25-year power purchase agreement (PPA) in North Carolina. The PPA was for the construction of Solar Farms and MIT gets the corresponding federal Renewable Energy Certificates (RECs).
- Stanford established a PPA to purchase RECs for 25 years from a Solar Generating Station in southern California. The university also buys the electricity generated.¹⁰²

Outcome:

- For Harvard, these actions generated 6% of the University's 30% achieved reduction.¹⁰³
- For MIT, these actions were the equivalent of removing almost 25,250 cars from the road and by keeping the RECs, MIT demonstrates renewable energy use equivalent to 40% of the total electricity use on campus.¹⁰⁴ Moreover, as the power is sold to the regional grid operator, the grid becomes greener.

6.2. Reinforcing feedback

The “Reinforcing feedback” approach consists in using avoided emissions from offsets to reduce net emissions in the medium-term. Additionally, it also includes a financial mechanism to charge for current carbon emissions rates to obtain resources to fund new offsets and direct emissions initiatives. That mechanism is often called a “carbon fund.” This approach results in reinforcing feedback which leads to reaching net zero emissions faster.

Figure 18 illustrates the system dynamics of this approach. On the diagram, there is one inflow of emissions (direct emissions rate) and one outflow (avoided emissions rate) - the net emissions is the inflow minus the outflow. As new offsets are created, the outflow increases, whereas when more direct emission reduction initiatives are created, the inflow decreases. Both mechanisms result in the stock of emissions decreasing.

¹⁰² "OP-1: Greenhouse Gas Emissions | Stanford University" Accessed May 17, 2018. <https://stars.aashe.org/institutions/stanford-university-ca/report/2017-06-28/OP/air-climate/OP-1/>.

¹⁰³ "Off-Site Emissions Reduction | Sustainability at Harvard." Accessed May 17, 2018. <https://green.harvard.edu/topics/climate-energy/site-emissions-reduction>.

¹⁰⁴ "MIT solar energy purchase addresses carbon emissions - MIT Facilities - Sustainability." Accessed May 17, 2018. <http://web.mit.edu/facilities/environmental/solar-ppa.html>.

Another important part of the diagram is the carbon fund resources, which depend on the current direct emissions rate. Those resources enable funding for new initiatives and offsets. However, if direct emissions go down, less funds are available for new investments, which creates a balancing feedback loop (Funding reductions on emissions). Additionally, direct emission reduction initiatives can result in economic savings, which can also be reinvested in new initiatives, generating a reinforcing feedback loop (Reinvestment from savings from initiatives). Besides, as more offsets are implemented, expenses from offsets increase, which decreases the willingness to invest in new offsets, creating a balancing feedback loop (Reduction on investments on offsets), consequently leaving more resources from the carbon fund available for direct emissions reduction initiatives.

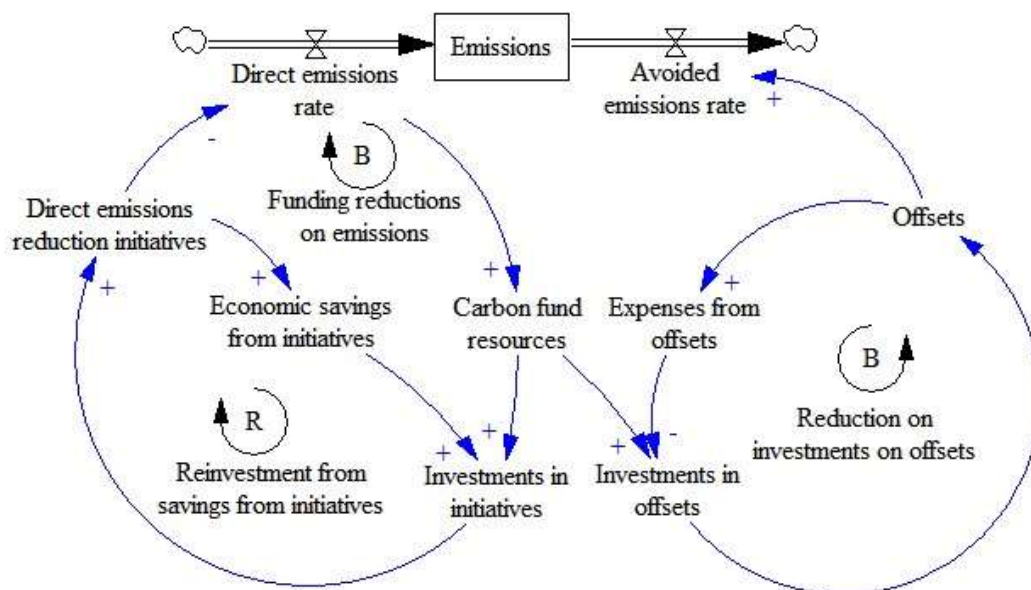


Figure 18: System Dynamics diagram of “Reinforcing feedback” approach

Some organizations have utilized this approach, as detailed in the following case study:

Case Example: *City of Cambridge Carbon Fund*

Context:

- Similar to Boston, Cambridge has adopted a carbon neutral target for 2050 and is considering how offsets, or offset like mechanisms, may play a role in achieving this objective.
- Building operations represent 79% of Cambridge’s total carbon emissions in 2012 and are thus the primary focus for emission reduction initiatives.¹⁰⁵
- Cambridge is committed to investing locally to reduce direct emissions before considering remote offsets in order to maximize the local GHG impact and co-benefits.¹⁰⁶

¹⁰⁵ “City of Cambridge Local Carbon Fund Feasibility Study”, Meisters Consulting and WattTime, April 2018, p. 5. (hereafter, Cambridge Carbon Fund, 2018)

¹⁰⁶ Cambridge Carbon Fund, 2018, pp. 15, 28.

Approach:

- Cambridge has established various tiers and timelines of emissions standards for residential, commercial, and institutional buildings within the city which will be tightened over time (to allow fewer emissions).¹⁰⁷
- To achieve their targets, buildings will have the option to either invest in direct emission reduction strategies (i.e., undertaking energy retrofits and upgrades) or to buy “offsets” by paying into a city-wide carbon fund.¹⁰⁸
- Cambridge intends to use the carbon fund, operated by a third party offset fund administrator, to finance or subsidize energy efficiency upgrades within the building stock to allow expensive retrofits or upgrades to happen sooner than market factors would otherwise dictate, and to address market failures which have prevented apparently economical investments for actually taking place. Ultimately, this funding will promote steady progress towards Cambridge’s goals of reducing direct emissions.
 - While the details are still being developed, it is likely that the offsets generated by any given project would only be produced for the time period by which the project was advanced through available funding (ahead of when it would otherwise have been financially viable, etc.). As offset projects expire, new projects must be funded or direct emissions mitigation undertaken in order to satisfy building standards thus increasing the cost of purchasing “offsets” from the fund over time. Eventually, Cambridge intends to phase out the offset optionality entirely.

Outcome:

- The design and implementation of this fund are still in progress and there may be opportunities for Boston to collaborate directly to scale impact.
- The intention is to accelerate the pace of direct emissions reductions within Cambridge’s residential and business housing stock to advance the city’s goal of carbon neutrality.

6.3. Last resort (in addition to direct reduction of emissions)

The “Last resort” approach consists of using offsets to account for residual direct emissions that could not be reduced in order to reach net zero emissions in the long-term. This approach is often used when the nature of the emission makes it hard to completely eliminate direct emission, such as scope 3 emissions, for instance, from transportation. It is important to realize that this is a potential strategy when considering what timing strategy is best given the circumstances.

Some organizations have utilized that approach, as detailed on the following case study:

Case Example: Austin TX’s “Good Traveler” program

¹⁰⁷ New construction and the existing building stock are also considered on separate timelines, see Cambridge Carbon Fund, 2018, p. 7.

¹⁰⁸ Cambridge Carbon Fund, 2018, pp 7-9.

Context:

- A majority of airplane travel relies on “dirty” technologies, so direct emissions reductions are fairly out of the hands of most industry players.
- Austin-Bergstrom Airport (AUS) continually lists “reducing our carbon footprint” among its annual goals.

Approach:

- In 2016, AUS partnered with The Good Traveler (a Rocky Mountain Institute group) to offer offset purchases to travelers flying in and out of the airport.
- The Good Traveler invests the money in verified and registered carbon offsets (VCS, Gold Standard, and Climate Action Reserve).

Outcome

- A \$2 purchase offsets the amount of carbon used in 1,000 miles of flying - approximately 344 lbs of CO₂.
- Consumers feel invested in making their travel greener, while airports solve the “last mile” problem associated with emissions in their business.

Case Example: Middlebury College offsets study travel**Context:**

In 2006, Middlebury wanted to be a leader for educational institutions to offer students a way to offset their emissions related to studying abroad.

Approach:

Middlebury coordinated with Native Energy to purchase carbon offsets for study abroad travel across a wide range of offset types and geographic areas.

Outcome:

These offsets supported projects related to renewable energy, methane digesters, household water filters and wind turbine.¹⁰⁹ While Middlebury no longer funds the offsets directly, students are still encouraged to purchase offsets through Native Energy.

Example: American University offsets emissions from commute to campus**Context:**

AU is committed to achieving carbon neutrality by 2020.

Approach:

- Plant 650 trees in Washington DC to offset the carbon emissions generated by the commute to campus by students, faculty and staff members.

¹⁰⁹ "Carbon Offset Program | Middlebury." Accessed May 17, 2018.
http://www.middlebury.edu/international/sa/sustainable/carbon_offsets.

- Additional interventions include, energy efficiency in buildings and renewable energy projects and RECs¹¹⁰
- Other companies that just bought RECs on the open market

7. Community choice aggregation as an emissions reduction strategy

One tool which could assist in achieving the city’s goal of net zero GHG emissions by 2050 is the establishment of a municipal electricity aggregation program, also known as community choice aggregation (CCA) or community choice energy. Such programs rely on “aggregat[ing] the electrical load of customers within their borders to procure competitive supply of electricity.”¹¹¹ Figure 18 illustrates how this program works.

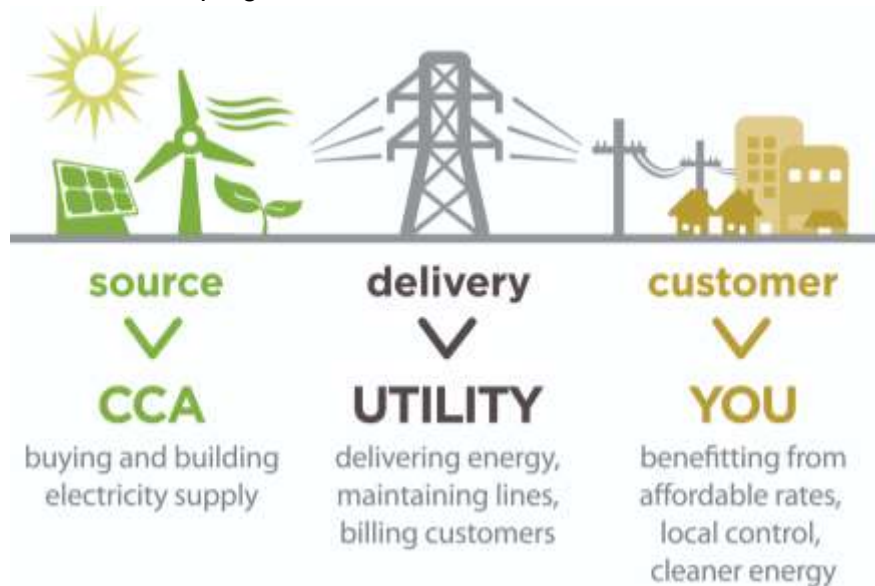


Figure 19: How local energy aggregation works¹¹²

By using this program, the city procures electric supply, on more competitive terms, on behalf of residents and businesses that choose to participate on a voluntary basis. It is also possible for Boston to join other municipalities.

Many municipalities in the US (including towns and cities in Massachusetts) have already established this system. Residents and businesses in Massachusetts can choose to buy their electricity from any approved energy supplier. In Boston, residents are automatically enrolled in

¹¹⁰ "American University Launches Innovative Carbon Offset Program in Washington D.C." Accessed May 17, 2018. <https://www.american.edu/media/news/20180418-Carbon-Offset-Program-Launched.cfm>.

¹¹¹ "Municipal aggregation | Mass.gov." Accessed May 17, 2018. <https://www.mass.gov/service-details/municipal-aggregation>.

¹¹² "Lean Energy U.S. – What is CCA." Accessed May 17, 2018. <http://www.leanenergyus.org/what-is-cca/>.

Eversource as the utility that by default delivers electricity¹¹³. However, at any time citizens can choose to change the supplier.

To better illustrate how the City of Boston could implement such a program, here is the example of the Cambridge Community Program.¹¹⁴ It has been established as a system where residents and businesses in the City are increasing the amount of renewable energy used for their electricity and has also resulted in decreased bill costs for consumers. The city of Cambridge continues receiving the service from Eversource and in addition, there is a competitive bid process for the electricity supplier, which currently is Agera Energy until January 2019.

The program in Cambridge offers residents and businesses to choose cleaner-energy options in addition to Eversource basic service (current cost is 12.888 ¢/kWh for residential customers):

- **Standard green:** Automatic default option of enrollment for customers since July 2017 (they can choose to opt-out at any time). It provides 25% more solar energy than currently required by the state. The projects are located in or near the City. The cost currently is 10.486 ¢/kWh.
- **100% green:** Optional plan with an easy enrollment process. It provides 100% renewable energy from projects in New England, 100% Massachusetts Class I Recs.¹¹⁵ The cost currently is 12.180 ¢/kWh for residential customers.

For the customers that choose to opt out from the program, Eversource continues as the electricity supplier.

Some of the benefits of the program include:

- Reduction in the electricity bill price for consumers and more consistent billing prices.
- Promotion of greener energy sources and use.
- Citizens' engagement in the achievement of the net GHG emissions goal by 2050.

However, there are some challenges to be considered for the establishment and promotion of a municipal electricity aggregation program, including the implementation, which could prove to be complex.¹¹⁶

Additional considerations for the City of Boston:

- Procurement of consulting services to manage the program. "One such approach would be for the City to pay for the services up front on an hourly or fixed fee basis"¹¹⁷.

¹¹³ "Responses to our RFI on municipal electricity aggregation program." Accessed May 17, 2018.

<https://www.boston.gov/news/responses-our-rfi-municipal-electricity-aggregation-program>.

¹¹⁴ "Cambridge - MassPowerChoice.com." Accessed May 17, 2018. <https://masspowerchoice.com/cambridge>.

¹¹⁵ "Options & Pricing - MassPowerChoice.com." Accessed May 17, 2018.

<https://masspowerchoice.com/cambridge/options-pricing>.

¹¹⁶ "The Good, the Bad, and the Ugly of Municipal Electricity Aggregation In Illinois." Accessed May 17, 2018.

<https://power2switch.com/blog/the-good-the-bad-and-the-ugly-of-municipal-electricity-aggregation-in-illinois/>.

¹¹⁷ "Responses to our RFI on municipal electricity aggregation program." Accessed May 17, 2018.

<https://www.boston.gov/news/responses-our-rfi-municipal-electricity-aggregation-program>.

- Procurement of electricity supply to achieve climate goals and the importance to include renewable sources in a voluntary basis, while taking care to not increase consumers' cost.
- Communications strategy and community engagement. Behavioral economics approach would recommend a system of automatic enrolment with an opt out option, as it is the case in other cities, such as Cambridge.

8. Conclusion and Key Takeaways

Our examination of the market for carbon offsets and RECs has produced several key takeaways for Boston which we highlight in this section.

First and foremost, though offsets and RECs have been criticized as ineffective mechanisms for reducing carbon emissions, as with any tool it is possible to use these mechanisms effectively or ineffectively. Effective usage requires acknowledging the primary drivers of controversy and addressing these factors head-on. Boston can address concerns about inducing moral hazard by using offsets and RECs as financial signals to internalize (and target) the social cost of carbon to further incentivize reductions in direct emissions. Additional concerns over equity can be addressed by using the purchases of offset or RECs as intentional tools for wealth redistribution. Finally, careful application of the rigorous PAVER+ criteria can help Boston insure that offsets and RECs are indeed generating credible reductions in net greenhouse gas reductions.

Boston will need to think critically about its objectives in adding offsets and RECs as a planning tool and how the concerns about these tools can be assuaged and the tools themselves leveraged most effectively. Boston will also need to decide how it values the PAVER+ criteria and what limitations, if any, these objectives and values place on potential program design of viable offsets and RECs. While there are a wide range of offsets to choose from, it is important for Boston to be intentional in selecting a specific offset, as well as designing how they choose to implement it. The case studies included throughout this report serve as examples of the variety of offsets that can be leveraged in a program, either by Boston itself or by its constituent members, and how programs can be designed differently to overcome a range of obstacles and achieve a diversity of objectives.

In terms of what's next for the city, we propose a few brainstorming discussions to be had when the time comes to design an offset project:

- **Identify stakeholders:** Who are the key stakeholders? Before limiting the scope of projects, identify who the important parties are economically, politically, and technically. Also make it clear who a project lead would be - ideally this would be the city of Boston leading a consortium of universities, non-profits, and other local cities to develop economies of scale in the procurement process.

- **Pool resources:** Among the key stakeholders, what are the resources available? What are the city's strengths and weaknesses when it comes to large scale energy projects? Identifying strengths the city can rely on while also identifying weaknesses that might be improved upon can set the project on the right course.
- **Outline realistic project specifications:**
 - ***Institutional objectives*** - are stakeholders looking to align this project with their internal objectives?
 - ***PAVER+ criteria*** - which criteria are most important to prioritize?
 - ***Carbon potential*** - how much of the City's emissions will need to be offset?
 - ***Budget*** - what's a realistic budget that will satisfy project goals
 - ***Timing*** - is the City aiming for a "quick win"? A "reinforcing feedback" system? Or offsets as a "last resort" after prioritizing a series of direct emissions reductions?
 - ***Politics*** - are there political initiatives that the city can join forces with to give the project support?

Once these specifications are identified, the City will be able to move forward with the decision making process around offset projects with a trained eye towards what is best for them. The offset landscape is changing drastically, and we have heard from numerous insiders that what you see today could look totally new and improved in a years time. There is no one-size-fits-all offset for every situation, nor is there likely a perfect offset for the City - but there are options out there that satisfy the key offset criteria, while also benefiting the City on a broad scale.

9. Appendix

9.1. Project reflections

Overall, this project was a great learning experience for the team members. The topic was highly technical and there was a steep learning curve on Offsets and RECs, which required a lot of literature research, interviews and benchmarking analysis. Some types of information were more challenging to obtain, such as offset financials and risk factors. However, the contacts and sources suggested by the faculty and our colleagues ultimately provided us with a strong starting point for our work. In addition, the team had to develop problem solving skills to create a framework in order to clearly structure and communicate the key messages about offsets: concepts, advantages and risks of each type of offset, as well as the different design approaches for offset programs.

In addition, having the opportunity to be involved in a project with such tangible significant gave us substantial motivation and perspective. The study we produced will be used by the City of Boston as an input to define its strategy to reach carbon neutrality and ultimately has the potential to have a great impact not only for Boston, but also in other cities that may follow its example. That perspective gave a high level of motivation to the team, which was committed to deliver a report that could provide the city with the information it need to make the best decisions regarding offsets and RECs.

And importantly, it was also an experience to improve teamwork skills. The team divided tasks in order to make sure all members were involved in all phases of the projects to proper balance the workload and provide opportunity for learning and development. Theses phases included research, interview, presentations and writing. Another important topic was the engagement of our project host at the BU team, with whom the team had weekly meetings to check-in on the progress of the project. Although we did not have meetings with City of Boston representatives, this frequent contact with the host helped the team focus on the topics that were most relevant to the City's needs. Although it was a risk, that focus was eventually proved beneficial, as our research was very well received by city representatives in our final presentation.

9.2. Overview of Benchmarking case studies taken into account for this report

Cities and governments	Universities	Corporations
<ul style="list-style-type: none"> ●London ●Melbourne ●Copenhagen ●California ●Berlin ●San Francisco ●Boulder ●Cambridge ●Carbon Neutral Cities Alliance ●Seattle ●Palo Alto 	<ul style="list-style-type: none"> ●MIT ●Harvard ●The Duke Carbon Offsets Initiative ●Colgate University ●Stanford ●The Carbon offset Network: Duke, Oberlin College, U. of Florida ●American University 	<ul style="list-style-type: none"> ●Apple ●Google ●Facebook ●Biogen ●Microsoft ●Lyft