TAF

TAF Carbon Emissions Quantification Methodology

April 2023

Carbon emissions, or greenhouse gas (GHG) emissions, is a key metric used to assess human climate activity. To understand and reduce our impact on the environment, it is crucial to estimate existing emissions and the potential for reducing them. There are numerous approaches and factors to consider when quantifying as accurately and reasonably as possible I to identify and prioritize reduction measures.

TAF strives to inform all major projects, grant and investment decisions with rigorous quantification, and to report annually on their performance. We also use emissions quantification to explore new areas of potential reductions and to inform policy development.

Although procedures and techniques for quantification differ from case to case, they should all be transparent, consistent, rigorous, and use reliable data. TAF follows these essential principles to ensure quality results when calculating emissions reductions. TAF's general approach for all quantification activities is to establish a purpose, determine the boundary, collect activity/resource use data, apply emissions factors, and check reasonableness.

Considerations while quantifying emissions include additionality, double counting, interactive effects, the time value of carbon reductions, co-benefits, and cost effectiveness. These considerations will help improve estimates and prioritize of the most effective actions.

This document summarizes TAF's current practices, provides transparency, and aims to stimulate emissions quantification discussions and activities. Key updates in this edition include:

- Updated fuel combustion emissions factors for natural gas, electricity, gasoline, and diesel.
- Fugitive methane emissions factors
- Embodied emissions of Part 3 (exceeding 600 m^2 in building area) and Part 9 (low-rise) building materials where local, up-to-date information is available.

The methodology described here is intended for carbon reduction projects and not meant to be used in inventories which require a different approach. TAF's emissions inventory and methodology can be found on our website.

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ABOUT TAF

The Atmospheric Fund (TAF) is a regional climate agency that invests in low-carbon solutions in the Greater Toronto and Hamilton Area and helps scale them up for broad implementation. We are experienced leaders and collaborate with stakeholders in the private, public and non-profit sectors who have ideas and opportunities for reducing carbon emissions. Supported by endowment funds, we advance the most promising concepts by investing, providing grants, influencing policies and running programs. We're particularly interested in ideas that offer benefits in addition to carbon reduction such as improving people's health, creating local jobs, boosting urban resiliency, and contributing to a fair society. TAF is a proud member of the Low Carbon Cities Canada network.

taf.ca

CORE PRINCIPLES AND GOALS

TAF has an established practice involving GHG Quantification. Emissions quantification approaches can vary based on the objectives and constraints of each project. Despite this the underlying values and principles of GHG quantification should remain consistent. TAF strives to apply the following core principles to all GHG quantification efforts.

Credible: Draws from international best practice principles of The GHG Protocol/ISO 14064-2 including Consistency, Transparency, Accuracy, Relevance, Completeness, Conservativeness. This ensures that the overall process and emissions reduction calculations can be explained, validated and/or replicated in a simple and transparent manner.

Scalable: Complementary to the Low Carbon Cities Canada (LC3) Network scale-up metrics, allows for further analysis of potential GHG emission reductions at scale.

Informative: Serves to inform strategic decision-making and enable continuous program improvement.

Adaptable: Allows for consideration of local variables across TAF and the LC3 Network, including scope variability based on a spectrum of different project types.

Multifunctional: Leverages existing data sources, tools, and systems where appropriate in support of strategic analysis of overall GHG and other benefits (environmental, social, economic).

Practical: Level of rigor is appropriate to the mitigation action and balanced with a reasonable level of effort.

Our quantification efforts aim to achieve the following goals:

1. Evaluate the quality of a proposed project or program and determine the level of fit within TAF’s focus areas.
2. Measure the benefits that individual projects or programs achieve and report on progress.
3. Use the results to inform future work and climate action.

We use quantification to inform our work in the following key areas[1]:

Decision-making: GHG quantification is a critical component of TAF's decision-making process. It helps us identify the best ideas that can scale and accelerate emissions reductions across all our projects, grants, and impact investments.

Due diligence: We evaluate potential investment technologies and their readiness level, evaluating their carbon emission reduction potential.

Reporting and tracking organizational performance: The GHG quantification models, combined with ex-post analysis tools, allow us to track whether the work we undertake and fund achieves the expected outcomes. These tools are intended to evaluate both the performance of a particular project and the accuracy of our own evaluation. Undertaking GHG quantification systematically and consistently allows us to evaluate the total reduction potential and report on it.

Policy advocacy: Our GHG modeling and evaluations help quantify the benefits of climate action and enable us to focus on the most critical climate action policies.

Exploratory research: Our deep dive analysis and strategic deep dives aim to improve climate action and answer key research questions within our focus areas.

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[1] Based on Low Carbon Cities Canada (LC3) GHG emissions quantification methodology

KEY CONCEPTS

This section describes key GHG quantification concepts necessary to understand our emission calculations. A list of additional terms and abbreviations is provided in Appendix A.

Fundamental Unit

There are numerous GHGs such as nitrous oxide, methane, and carbon dioxide which absorb and radiate heat back to the earth's surface. To simplify and enable comparisons, these various gases are all converted to a fundamental unit for measuring GHG emissions: carbon dioxide equivalent (CO_2eq). GHGs are converted by their global warming potential (GWP) which is based on their ability to absorb and radiate back to the earth's surface relative to carbon dioxide (CO_2). Carbon dioxide serves as the baseline and has a GWP of 1. There are different GWP calculated over specific time horizons. TAF uses a timeframe of 100 years (GWP100) for emissions inventories and a timeframe of 20 years (GWP20) for all other types of quantification. Lastly, GHGs are measured by their mass (e.g., megatonnes, kilotonnes, tonnes, kilograms, or grams of CO_2eq).

Emissions Factors

Emissions factors are ratios between an activity or the use of a resource and the associated amount of CO_2eq released (or not released) as a result. The most commonly emissions factors are for the consumption (or conservation) of fossil fuels and electricity. TAF currently uses the below emissions factors. Other emissions factors are sometimes required, for example for waste diversion, and are generated on an as-needed basis based on best available data.

Resource	Factor	Unit	Data year
Natural Gas	1932	g CO_2eq/m^3	NIR 2020
Electricity (Average) [2]	47	g CO_2eq/kWh	TAF 2022
Electricity (Marginal) [3]	160	g CO_2eq/kWh	TAF 2022
Gasoline	2322	g CO_2eq/L	NIR 2020
Diesel	2709	g CO_2eq/L	NIR 2020

Table 1: Common Emissions Factors for Ontario

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[2] A Clearer View on Ontario's Emissions: Updated Electricity emissions factors and guidelines (TAF 2021)

[3] Ibid

Electricity Emissions Factors: Marginality and Time of Use

Emissions factors for electricity are typically more complex than emissions factors for direct fossil fuel combustion. First, the carbon intensity of grid-supplied electricity fluctuates significantly over time, varying based on time of day, seasonally, and year. Additionally, average emissions factors do not accurately represent the emissions reduction potential of electricity conservation or renewable energy generation, even if an average factor is weighted for time of use. This is because average emissions factors do not consider the response of the grid to marginal changes in electricity demand.

At any given point in time one specific generating resource is ‘on the margin’, meaning it will respond to an incremental increase or decrease in demand. A marginal emissions factor considers the source of electricity that is on the margin. By using a marginal emissions factor, a more accurate representation of the emissions reduction potential of conservation, renewable generation, or electricity storage is established. The marginal emissions factor can be calculated various ways and differ between electricity systems. Based on publicly available information from the Independent Electricity System Operator (IESO), TAF regularly updates our marginal emissions factors for electricity in Ontario.

When estimating the carbon footprint of an entity — whether it is a city, an organization, or a building — TAF uses an average emissions factor. When estimating the emissions reduction potential of specific projects or policies, TAF uses a marginal emissions factor. If the electricity conservation/generation measure(s) being quantified has a known temporal profile, a time of use weighted marginal emissions factor is recommended. In the absence of such information, an annual marginal factor provides a good approximation of emissions reduction potential. When comparing percentage reductions, the same emissions factor is used to quantify the baseline and the impact. Average and marginal electricity emissions factors for future years can be found in Appendix B. More detailed information about how to use the different electricity emissions factors, data sources, and the methodology behind their development can be found in our guide.

Fugitive Natural Gas Emissions Factor

Quantifying the full impact of natural gas consumption requires looking beyond combustion emissions, since a significant portion of emissions come from other stages of the natural gas life cycle. Methane leaks into the atmosphere during extraction, transmission, and local distribution. TAF’s report[4] on fugitive methane shows a 40% - 90% increase in total emissions when looking at the full life cycle of natural gas, including extraction and long-distance

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[4] TAF_Fugitive-methane-guidelines_2022-2.pdf

transmission. In our fugitive methane report, we have established a set of criteria to account for each stage of the life cycle resulting in a 2.7% leakage rate.

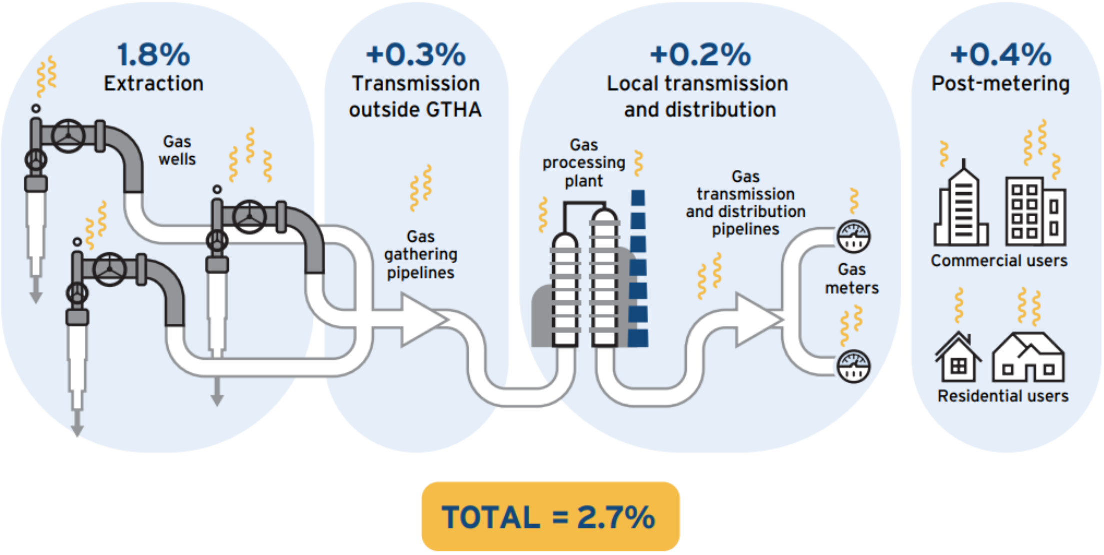

Figure 1: Estimated rates of methane leakage across then natural gas life cycle

Table 2 summarizes the natural gas emission factor with a GWP20 to estimate the upstream fugitive emissions of natural gas in TAF's projects and GWP100 for inventory purposes. Detailed information about how to use the different natural gas emissions factors, data sources, and methodology used to calculate them, can be found in our methane report. The factors presented in this guide account only for direct (combustion) emissions, and thus can underestimate the global impact of interventions.

Purpose	GWP	Natural Gas (kgCO2eq/m3)	Natural Gas LCA (kgCO2eq/m3)[56]
Inventory	100	1.93	2.48
Projects without impacts to natural gas pipeline infrastructure	20	1.93	3.16
Projects that impact natural gas pipeline infrastructure	20	1.93	3.68
Renewable natural gas projects	20	1.93	3.34

Table 2: GWP and natural gas emission factors

GENERAL APPROACH

TAF’s fundamental approach to GHG quantification follows the below process:

Figure 2: TAF’s General GHG Quantification Process

Establishing a Purpose

The purpose of the quantification should be determined as a first step so that the results meet the needs. Below are some common reasons for GHG quantification and some considerations to be made based on the identified needs.

Purpose	Consideration
Identify opportunities for reduction	Granularity and context required to identify actions that can lead to significant reductions.
Track emissions between years	Consistency of methods and data to compare between years; and consideration of potential future changes.
Meet regulatory requirements	Ensuring the process and output follow the regulation requirements.
Quantifying the reduction potential	Establishing a fair and consistent baseline and alternative scenario(s).

Table 3: Common Purposes and Related Considerations for GHG Quantification

Boundary and Scope

When quantifying GHG emissions it is important and useful to create a boundary around the emissions which will be calculated. The boundary, for example, can be physical, organizational, or jurisdictional. Boundaries can be set to focus on specific emissions sources, to encompass a specific responsible party, or to serve another purpose of the quantification.

Part of establishing a boundary is also determining a scope which usually refers to the type of emissions to be quantified. Below are descriptions of conventional project scopes as established by the Greenhouse Gas Protocol, an internationally recognized guide for quantifying GHG emissions. If a GHG reduction potential is being calculated, then the boundary and scope between the baseline and alternative scenario(s) should be consistent unless there is a sound reason for them to be different.

Scope	Description	Example
1 (Direct)	Emissions from sources that are owned or controlled by the organization	Natural gas burned by a boiler within a building
2 (Indirect Electricity and Heat)	Emissions from the consumption of purchased electricity, steam, or other sources of energy generated upstream from the organization	The purchased electricity that is used for lighting within a building
3 (Other Indirect)	All other indirect emissions of an organization, both upstream and downstream.	The embodied carbon emissions associated with manufacturing the materials used to construct a building.

Table 4: Scopes According to the GHG Protocol

Generally, only Scope 1 and 2 emissions are calculated for projects. This is because influence over Scope 3 emissions is largely beyond an organization's control. Also, assessing Scope 3 emissions is more difficult and quantification methodologies in this area are less developed. However, recent studies have shown that Scope 3 emissions can be significant, especially when considering things like fugitive methane and embodied emissions.

Embodied carbon emissions of building materials are associated with the extraction of raw materials, manufacturing, transporting, and end of life. We propose bringing embodied carbon to the forefront of the analysis. Embodied carbon should be assessed whenever a project involves a significant amount of carbon intensive materials such as concrete and steel. Including embodied carbon in the analysis provides a more comprehensive picture of actual carbon impacts, and encourages the consideration of alternative, lower carbon materials and designs.

TAF has funded several studies on assessing the embodied emissions in new buildings materials. The Emissions of Materials Benchmark Assessment for Residential Construction (EMBARC) study[5] benchmarked the embodied emissions of residential construction materials and showed that Part 9 residential buildings constructed in the GTHA each year account for 191 kgCO2e/m². In another TAF funded study, embodied carbon benchmarks for Part 3

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[5] https://www.passivebuildings.ca/_files/ugd/833b9c_f872cdf803c34eec9acc7f0ef3840efc.pdf

buildings in the Greater Toronto-Hamilton Area[6], showed that Part 3 large residential and commercial building materials account for 435 kgCO2e/m^2 and 367 kgCO2e/m^2, respectively.

We use the Builders for Climate Action's BEAM [7] to estimate embodied carbon emissions in new construction projects as well as in existing building retrofits where there is a significant use of concrete, steel, and insulation. Two examples of embodied emissions quantification for TAF's projects are provided in Appendix B for reference.

Usage/Activity Data

Once the boundary and scope are established, the fundamental activity or resource use which generates emissions is identified. If the organization is seeking to reduce its emissions, then it might be more useful to gather contextual data such as how much electricity is used to power computers or what portion of total emissions air travel represents, for example. If an organization is simply reporting its GHG emissions then it might be sufficient to convert the gasoline, electricity and natural gas consumption of that organization directly into GHG emissions without a breakdown by activity.

If a potential reduction in emissions is being quantified, then activity/usage data for the baseline and alternative scenarios need to be obtained. The alternative scenario could be a completely different activity/resource use or less use of the same activity/resource. For example, estimating the GHG differences between ways to get from home to work. If someone is currently driving a gasoline vehicle and considering switching to an electric vehicle, then driving the gasoline vehicle would be considered the baseline while driving an electric vehicle could be the alternative. The main difference between the two would be the emissions produced per distance travelled.

Applying Emissions Factors

Multiplying the activities or resource usage by their corresponding emissions factors produces a final GHG emissions number. For example, if 1,000 L of gasoline is consumed by an organization in a year then multiplying that value by the gasoline emissions factor of 0.0023 tCO_2eq/L results in a total GHG emissions of 2.3 tCO_2eq that year.

If a potential reduction in emissions is being quantified, then the difference in emissions between the baseline and alternative scenario is the potential reduction. Additionally, special attention should be paid to ensuring consistent units and timeframes.

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[6] Mantledev- benchmarking-of-embodied-carbon-for-large-buildings
[7] https://www.buildersforclimateaction.org/beam-estimator.html

Check Reasonableness

If possible, the resulting GHG quantity should be validated to check if the savings are reasonable for the given activity. For example, if a building is estimated to reduce its GHG emissions by 50% simply by installing a new chiller then the calculations need to be revisited, as experience shows that additional measures are needed to achieve such a large reduction.

KEY OUTPUTS

The output of TAF's GHG quantification analyses is usually an estimated impact on carbon emissions but, depending on purpose of the analysis, it may be presented as an annual impact or a cumulative impact over a defined time horizon. Generally, TAF's primary focus in quantification is on the cumulative GHG reduction potential. Below is a list of GHG metrics that are commonly generated as part of our quantification activities.

Cumulative GHG Reduction Potential

An assessment of the total GHG reduction potential associated with a project, policy, technology, or other initiative over a time horizon of up to 20 years. Assessment is based on how quickly the initiative could take effect and scale up to its maximum potential. For some projects, a discount rate of 5% per year is applied to future GHG reductions and then added together to determine a Carbon Net Present Value, or CNPV.

Average Annual GHG Reduction Potential

This is the average of the GHG reduction potential quantified for all projects, policies, technologies, or other initiatives each year. This is equivalent to the cumulative GHG potential divided by the number of years in the time horizon.

Cumulative Direct GHG Reduction

We quantify the direct GHG impacts up to a 20-year time horizon. Direct emissions refer to emissions that TAF or a TAF partner controls and has immediate influence over. For example, with investments in energy retrofit projects or renewable energy projects, the project will lead directly to GHG reductions. The time horizon is established based on the expected life of the project. The project may or may not also have a scale-up potential that is separately assessed. A CNPV may also be calculated for these types of GHG reductions.

Average Annual Direct GHG Reduction

An average of the annual direct GHG reduction estimate for a project. Equivalent to the cumulative direct GHG reduction divided by the number of years in the time horizon.

ADDITIONAL CONSIDERATIONS

GHG quantification can be complex to perform. Understanding the concepts in this section can help inform the process and improve the utility of the GHG emissions values produced.

Additionality

When assessing alternative scenarios, it is important to consider what changes in the baseline might have occurred without those alternatives. There might be cases where some change would have happened without a particular intervention due to other priorities or general trends in that area. For example, it would be unreasonable to estimate that installing 1,000 new electric vehicle charging stations across the GTHA are solely responsible for the increase in electric vehicle purchases afterwards. The new charging stations may be responsible for a *portion* of that increase, but other factors such as availability, vehicle cost, and incentives can also play a major role.

Double Counting

Double counting is when calculations of emissions are added together despite having some overlap. One potential cause of this is emissions activities which cross boundaries or projects which overlap. For example, if someone drove from Mississauga to Toronto and both cities counted the emissions of that drive, then those emissions were double counted. In this example, caution should be taken when adding the emissions of both cities to determine the larger, regional impacts.

Interactive Effects

It is important to consider the impacts that multiple, related emissions reduction interventions have on each other. If more efficient water fixtures *and* a heat pump water heater were installed at the same time in a building, simply combining each individual measure's reductions to obtain the collective impact would result in an overestimation of savings. Accounting for such interactive effects will produce more accurate GHG estimates.

Time Value

It is critical to consider the urgency of emissions reductions due to the increased difficulty and the diminished impacts of reducing them in the future. Making decisions today which increases emissions may also increase the difficulty and cost of implementing an alternative sometime the future. For example, it is far easier and cheaper to initially construct an efficient home than it is to construct an inefficient home and retrofit it later on. Further, delaying emissions reduction actions can severely impact the climate, causing irreversible damage. Reductions that can be achieved quickly are more valuable – assuming they do not preclude the opportunity to achieve deeper subsequent reductions.

Cost Effectiveness

One factor that can be helpful in evaluating various GHG reduction strategies is the cost effectiveness of each strategy. Cost effectiveness is typically evaluated as $/$tCO_2$eq reduced but this can be calculated in various ways. The most holistic way would be to include the cumulative GHG reductions over the life of the project/measure, the total capital cost to all parties, as well as the cumulative on-going cost and cost savings (if applicable) over the same time frame. The 'cost' per tonne of some emissions reduction strategies can be negative since reducing emissions typically means reducing resource consumption which in the long run can result in net savings.

Other metrics include direct and potential cost per tonne of direct emissions reductions. Direct emissions are ones that TAF or a TAF partner controls and has immediate influence over and direct costs are capital costs spent by TAF whereas potential cost per tonnes captures capital costs spent by TAF and TAF partners. Both metrics have advantages and disadvantages depending on the type of project and the information needed and they both do not include ongoing costs or cost savings of the project. Direct cost per tonne is useful for projects where there's a high degree of confidence of immediate emissions reductions. Total project cost per tonne better used on broader projects where the reductions occur across a wider geographical area or demographics.

Time Horizon and Scale-up Pathway

Depending on the purpose of the quantification, a time horizon is selected for the analysis. Typically, TAF applies a 20-year time horizon. If the purpose of the analysis is to quantify potential emissions reductions, assumptions must also be made about how quickly a climate change mitigation measure and the resulting GHG impact could scale over time. For example, the scale-up pathway for a policy reform initiative would reflect assumptions about when the policy might take effect, whereas the scale-up pathway for a new technology would reflect assumption about market adoption potential.

Co-Benefits

Environmentally beneficial projects often result in co-benefits in employment, economic stimulus, health and other areas. It is valuable to consider them when examining projects.

TAF calculates job-years created (18/$1M of energy efficient program spending) and the increase in GDP ($2.5/$1 of energy efficient program spending) using values from Acadia

Center's report *Energy Efficiency: Engine of Economic Growth in Canada*[8]. Both values are calculated only for building energy efficiency projects and are based on total project costs. TAF will continue to investigate the latest research in these types of co-benefits and update our methodology as needed.

Ambient levels of criteria air contaminants (CACs) are one of the key connections between GHG reduction activities and health. TAF calculates natural gas CAC emissions using residential natural gas combustion values from the *Criteria Air Contaminants Emissions Inventory 2006 Guidebook*[9]. We take natural gas electric power generation values from the same source and combine them with TAF's marginal electricity emissions factors to calculate CAC emissions reduction from electricity conservation. We calculate vehicular CAC emissions using values from *Transport Canada's Urban Transport Emissions Calculator*[10]. More sophisticated modeling is required for converting these reductions in emissions to changes in ambient levels of CACs and thus health impacts. For example, to monetize the health co-benefits of the ZEV sales mandate, TAF used Health Canada's benefits per tonne (BPTs) metrics[11] as well as criteria air contaminant factors and fuel savings to monetize the expected health co-benefits of this policy.

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[8] https://acadiacenter.org/wp-content/uploads/2014/11/ENEAcadiaCenter_EnergyEfficiencyEngineofEconomicGrowthinCanada_EN_FINAL_2014_1114.pdf

[9] http://publications.gc.ca/collections/collection_2019/eccc/En40-895-2008-eng.pdf

[10] Tables available here: https://www.peelregion.ca/planning/climatechange/reports/pdf/Region-of-Peel-GhG-and-CAC-Community-Reort.pdf

[11] https://publications.gc.ca/collections/collection_2022/sc-hc/H144-111-2022-eng.pdf

OPERATIONAL PRACTICES

This section describes a few specific considerations and approaches to GHG quantification based on the type of analysis.

Grants

TAF provides grants to projects which demonstrate a significant cumulative GHG reduction potential. Using the information provided by a potential grantee and additional research performed by TAF, an emissions reduction potential is determined for each year of the project's lifetime (up to a maximum of 20 years) to calculate the CNPV. The CNPV is then converted to a score out of 20 for quantifiable grants. A CNPV of 2,000,000 tCO2eq or more is given the highest score possible (20) while lower CNPVs are scored proportionally. An external probability of success is scored out of 5 and added to the GHG score of 20. The total GHG score (out of 25) along with other scores which assess the qualitative aspects of the grant proposal are presented to TAF's Grants and Programs Committee and Board to help inform their decision making. Non-quantifiable grants with no GHG score are qualitatively scored out of 75 and a scaled to 100 for decision making.

Key Performance Indicator

To track organizational progress towards the goal of combating climate change, TAF tracks the GHG reduction potential of the projects it supports as one of our key performance indicators. The cumulative GHG reduction potential from all grants, direct investments, and other projects initiated each year are added together to create the GHG KPI for that year. This cumulative potential is *not* a prediction of the carbon reduction that will result directly from TAF supported initiatives; it is an assessment of the long-term scale-up *potential* of the climate solutions (like policies, programs, technologies, or business models) that TAF-funded initiatives are intended to advance or demonstrate. We also present a rolling 3-year average to help evaluate longer-term trends and evaluate TAF's success in finding high impact climate solutions to support and invest in. This methodology does not account for interactions between projects as it's not intended to reflect the *actual* reductions, and in some cases may have double counting.

Direct Investments

Part of TAF's GHG reduction strategy is to fund projects with direct emissions reductions. Direct investments typically aim to reduce a specific quantity of resource consumption (such as cubic metres of natural gas). This type of reduction is intended to be well supported by evidence and thus can be estimated fairly accurately a prior to pursuing the project. This reduction potential is assessed along with financial parameters and plan to measure the actual savings. After an investment is approved, a measurement and verification (M&V) plan is typically implemented, and savings are continuously monitored to ensure the investment objectives are met. In some cases, direct investments also have a scale-up potential that is assessed (like seed funding for a renewable energy cooperative that is expected to leverage that investment by raising private capital in the marketplace).

Exploratory Research

TAF continually explores new areas, technologies, methods, and policies for GHG reduction. These types of ideas generally carry greater uncertainty and GHG emission reductions are usually on an order of magnitude scale. However, exploratory research can uncover significant areas of emissions reduction potential and is a valuable effort worth pursuing. Further analyzing the impacts of Scope 3 emissions is one example of emissions which could be significant and have a high reduction potential.

Internal Projects

TAF also pursues GHG reduction projects which it internally cultivates and manages. Direct and potential emissions impacts of these internal projects are assessed similarly to direct investments.

Policy Impacts

Many internal projects and grants funded by TAF focus partly or wholly on policy solutions to climate change. Historical analysis of TAF’s performance shows that the biggest reductions we have supported have come from policy-related outcomes. Some policies pursued locally mimic existing policies in other jurisdictions so emissions reductions estimates can be modelled based on existing examples. However, differences between the economic, political and social climate of different jurisdictions may affect the transferability of impacts and require careful review. Policy impacts are often broad and can affect a large portion of a jurisdiction’s emissions, so the scale-up potential, breadth of impact, and depth of impact need to be given careful consideration.

HISTORICAL GHG IMPACT POTENTIAL

TAF reports the total cumulative GHG reduction potential of all TAF-supported initiatives each year as part of our annual reporting, as well as historical figures for comparison. The table below illustrates the total cumulative GHG reduction potential, over the lifecycle of those projects (up to 20 years). The annual average cumulative GHG reduction potential over TAF's history is 16.5 $MtCO_2eq$, meaning that in a typical year, TAF supports initiatives with an estimated 20-year reduction potential of 16.5 $MtCO_2eq$. TAF's endowment has grown substantially in recent years – the Province of Ontario contributed $17 million in 2016; the Government of Canada $40 million in 2019 – so we have supported more initiatives and improved the average.

Historical Period	Cumulative GHG Reduction Potential from TAF supported Projects	
	Total Cumulative GHG Reduction Potential ($MtCO_2eq$)[12]	Average Cumulative GHG Reduction Potential ($MtCO_2eq$/year)
Pre-2010	105	5.8
2011-2014	42	10.5
2015-2017	43	14.3
2018-2022	199	39.8
1993-2022	495	16.5

Table 5: Historical cumulative GHG reduction potential

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[12] Reductions prior to 2017 are based on activities focused on the City of Toronto (prior to TAF's focus expanding to the GTHA)

APPENDIX A: TERMS AND ABBREVIATIONS

Baseline scenario: A theoretical situation intended to reflect what would occur without any GHG reduction interventions.

Carbon Dioxide (CO_2): A molecule consisting of a carbon atom and two oxygen atoms. Carbon dioxide is a common greenhouse gas.

Carbon Dioxide Equivalent (CO_2eq): A common unit of various greenhouse gases that are converted based on their global warming potential.

Carbon Net Present Value (CNPV): The quantity of CO_2eq produced or reduced during the project lifetime discounted to the present in order to account for the reduced impact in the future (that is, the time value of carbon).

Emissions Factor (EF): A ratio of greenhouse gas emissions to the use of a resource, typically the burning of fossil fuel.

Greenhouse Gas (GHG): A gas which absorbs and reradiates infrared radiation which contributes to the greenhouse gas effect.

Global Warming Potential (GWP): A factor applied to greenhouse gases based on their greenhouse gas effect potency relative to CO_2.

Marginal Emissions Factor (MEF): A ratio of greenhouse gas emissions to the use of a resource which attempts to reflect the actual emissions reduced by accounting for factors such as the time of consumption.

Project Lifetime: A duration encompassing when a project produces or reduces emissions up to a maximum of 20 years.

APPENDIX B: QUANTIFICATION EXAMPLE

Example 1: *A design team is evaluating two envelope options for a low-rise multifamily building: prefabricated Structural Insulated Panels (SIPs) with EPS foam between OSB boards and Insulated Concrete Form (ICFs). Approximately 500 m^2 of panels are needed for this project. The embodied carbon emissions of both wall types are calculated below using the BEAM estimator.*

ICF-EPS foam (EPS foam ICF R23, 2 Sheets of 2.75" @ R4/in., 15M rebar with Concrete - 0-25 MPa, Canadian Benchmark Average) net carbon emissions = 73 kg CO2eq/m^2

ICF -EPS foam: 73 kg/m2 x 500 m2 =36.5 tonne CO2eq embodied carbon emissions

Prefabricated SIP panels (R23 6.5" - EPS 5.5" @ R4/in. core, 2 sheets 1/2" OSB) net carbon emissions= 21 kg CO2eq/m^2
Prefabricated SIP panel: 21 kg/m^2 x 500 m^2 = 10.5 tonne CO2eq embodied carbon emissions

Emission saved by using the SIPs: 36.5 - 10.5 = 26 kg CO2eq embodied carbon emissions

Example 2: *A local municipality is planning to construct 10 new multi residential buildings with an average floor area of 150,000 sq.ft. The total embodied emission associated with these building is calculated as follows:*

Average upfront embodied emission for a typical Part 3 building = 435 kg CO2eq/m^2[13]
Total embodied carbon = 10 x 13,935m^2 x 435 kg/m^2 = 60,617 tonne CO2eq.

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[13] Mantledev- benchmarking-of-embodied-carbon-for-large-buildings