Scope 3 Emissions from Fuel & Energy Activities

Category Overview: Definition, Boundary, Methodology, and Preliminary Results

Executive Summary

Scope 3 emissions from Fuel and Energy Activities are calculated on a regular basis for Stanford University by the Scope 3 Emissions Program in Business Affairs. This paper details the boundary and methodology for developing baseline Fuel and Energy Activities emissions for calendar year 2019. More information on the Scope 3 Emissions Program and baseline calculations in other scope 3 emissions categories can be found in the Stanford University CY2019 Scope 3 Emissions Program Description & Inventory.

Scope 3 emissions from Fuel and Energy Activities are classified as emissions in the following three categories:[1]

- **Upstream emissions associated with fuels directly combusted by the university**: extraction, production, and transportation of fuels consumed by the reporting company. At Stanford, this includes natural gas used for back-up heating production at the Central Energy Facility (CEF); natural gas used in individual buildings for cooking, water heating, lab equipment and heating equipment (for buildings not connected to the Central Energy Facility); and gasoline and diesel used in the mobile fleet. Emissions from the combustion of these fuels by the University are considered Scope 1 Emissions and are excluded from this category.
- **Upstream emissions of electricity purchased by the university**: extraction, production, and transportation of fuels or materials used in the generation of electricity consumed by the reporting company. At Stanford, this includes:
  - Life cycle emissions of solar panels at university-catalyzed solar facilities
  - Upstream emissions from grid electricity associated with the portion of Stanford's electricity consumption not matched by solar inputs onto the grid
- **Transmission and distribution (T&D) losses**: all emissions associated with generation of electricity lost in a T&D system. In the United States, an average of 5.1% of electricity produced is lost in transmission and distribution. [2]

Based on the above methodology, Stanford generated 23,723 metric tons of carbon dioxide equivalent (MTCO2e) of scope 3 emissions in calendar year 2019 (CY19), exceeding the scope 1 & 2 emissions generated from their direct consumption. For perspective, these scope 3 emissions are equal to 12% of Stanford's peak combined scope 1 & 2 emissions of 198,349 MTCO2e in 2011. Figure 1 below shows a breakdown of these emissions by end use.

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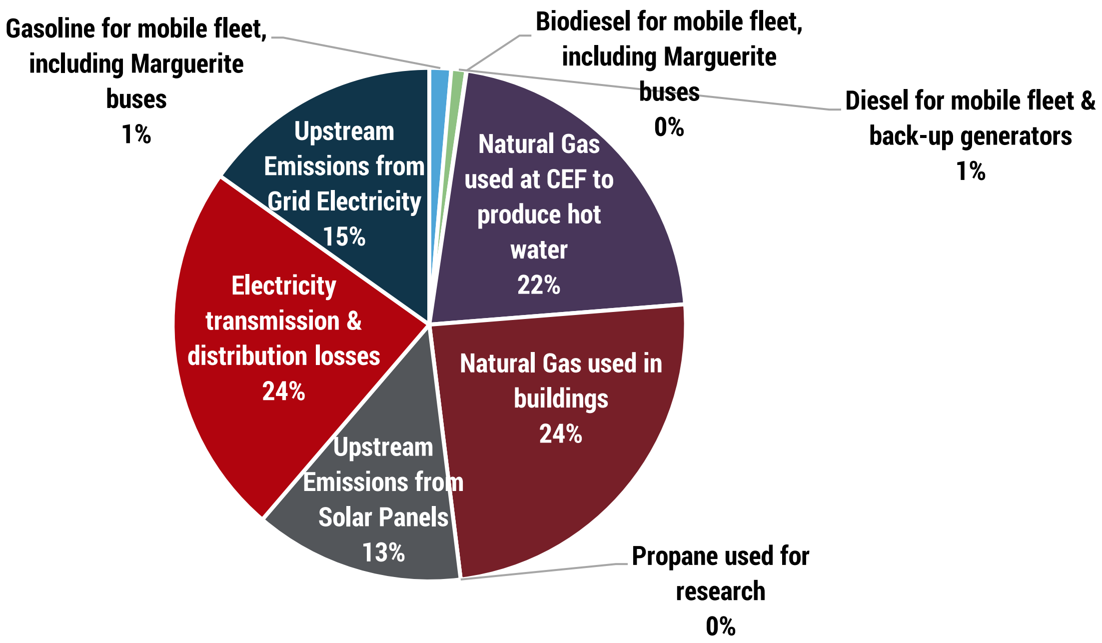
[1] Greenhouse Gas Protocol. "Technical Guidance for Calculating Scope 3 Emissions." World Resource Institute. 2013. https://ghgprotocol.org/sites/default/files/standards/Scope3_Calculation_Guidance_0.pdf

[2] Environmental Protection Agency. "eGRID Summary Tables 2019." EPA. February 23, 2021. https://www.epa.gov/sites/default/files/2021-02/documents/egrid2019_summary_tables.pdf

Figure 1: **Breakdown of CY19 Scope 3 Fuel and Energy Emissions by Fuel Source**



The emissions from fuel and energy activities on campus are based on fuel and electricity consumption data, which is also used to calculate Scope 1 and 2 emissions. This data was input into two third party tools and one internal model using publicly available emission factors. In turn, each of these were used to calculate scope 3 emissions from fuel and energy. The inputs and outputs of these tools were then compared to determine the tool most relevant to Stanford's energy use profile. Based on the winning tool—the Carbon360 platform from VitalMetrics—calculation of emissions in this category involves the following steps and data sources:

- Gathering of utility bill data and purchase records for fuel and electricity consumption (this step is completed by the Office of Sustainability to complete the annual Scope 1 and 2 greenhouse gas emissions inventory)
- Estimation of upstream emissions from fuel, using emissions factors from the EPA for gasoline, diesel, and biodiesel, and emissions factors from the National Energy Technology Laboratory (NETL) for natural gas
- Estimation of upstream emissions from grid electricity for the 42% of Stanford's electricity consumption that is not offset by solar added onto the grid. We use emissions factors from the Comprehensive Environmental Data Archive (CEDA) and the EPA for subregions of the electric grid from which Stanford receives electricity.
- Estimation of upstream emissions from solar panels using a harmonization study of solar panel life cycle emissions.[3]
- Estimating the amount of power lost in transmission and distribution in delivering the electricity consumed by Stanford and determining the emissions associated with the supply chain and generation of that electricity using EPA and CEDA

As shown in Figure 1, 46% of Stanford's scope 3 emissions from fuel and energy are associated with natural gas. Stanford's end uses for natural gas are to be decarbonized by 2040 based on existing university programs.

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[3] Kim, H.; Fthenakis, V.; Choi, J.; Turney, D. (2012). "Life Cycle Greenhouse Gas Emissions of Thin-film Photovoltaic Electricity Generation Systematic Review and Harmonization." *Journal of Industrial Ecology* (16:S1); pp.S110-S121.

Another 52% of Stanford's emissions in this category derive from electricity use. With the opening of the Stanford Solar Generating Station 2 (SSGS2) in March 2022, the 15% of upstream emissions from grid electricity will drop to zero, based on Stanford's custom methodology. To account for the life cycle emissions of the solar panels at SSGS2, an estimated annual 3,689 MTCO2e will be added in the upstream emissions from solar panels category at that time. However, SSGS2 produces more electricity than the university consumes, so as the university's electricity use increases due to campus growth and comes closer to matching total solar output, annual emissions from solar panels will remain relatively constant, rather than increasing (as they would in the alternative scenario), resulting in a significant long-term emissions decrease compared to the baseline scenario.

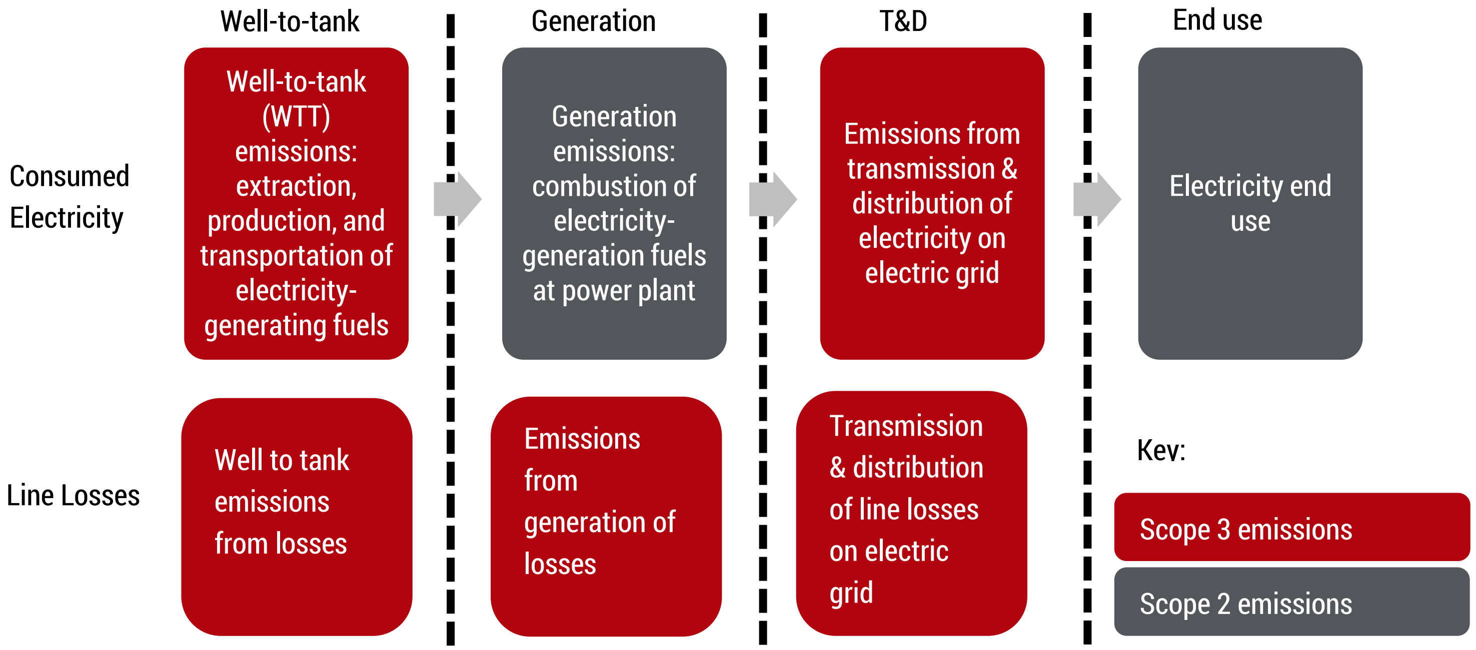
Overall, the university is already headed in a promising direction to significantly decrease scope 3 emissions from fuel and energy by 2050. While the Scope 3 Emissions Program will continue to quantify these emissions on an annual basis, we do not recommend the creation of additional programs to mitigate these emissions at this time.

Category Definition

The scope 3 Fuel & Energy Activities category extends the scope of emissions analysis beyond that included in scope 1 & 2 emissions to include the emissions associated with extraction, transport, refining, purification and/or conversion of primary fuels to fuels for direct use by end-users, as well as the distribution and losses associated with these fuels. See the Executive Summary for a detailed definition.

For fuels such as natural gas that are directly combusted at Stanford, all scope 3 emissions are associated with their supply chain. On the other hand, for electricity used at Stanford, scope 3 emissions comprise both the supply chain for the fuels and materials used to generate the electricity, as well as all emissions associated with electricity losses on the grid. To elucidate this concept, the life cycle stages for electricity are shown in Figure 2 below. Note that there is a fourth category of Fuel and Energy Activities defined by the GHG Protocol—Generation of purchased electricity that is sold to end users—that is only applicable to utility companies and energy retailers and thus will not be discussed in this paper.

<u>Figure 2:</u> Electricity Life Cycle and Corresponding Emissions Scopes



Category Boundary

Physical Boundary

The physical boundaries used for the Scope 1 & 2 emissions inventory conducted by the Office of Sustainability apply to this Scope 3 category, which is defined as all fuel and energy consumption related to business in Stanford's operational control within the United States. This includes fuel & energy used on Stanford's main campus, the Stanford Redwood City campus, and other satellite operations within the United States. It excludes fuel & energy used in Faculty Staff Housing and SLAC.

Unlike Scope 1 & 2 reporting, the electricity used to produce heating and cooling provided by the Central Energy Facility to the hospitals is included in scope 3 fuel & energy emissions; while Stanford University is not considered to have operational control over the hospitals, it does have control over the energy provided to the hospitals by the Central Energy Facility.

Data Boundary

As with other scope 3 categories, Scope 3 Emissions Program staff have prioritized a robust and holistic boundary for Fuel and Energy Activities that also prioritizes alignment with existing renewable energy investments to more fully account for the impacts of our solar facilities while avoiding double counting. To that end, we have made the decision to account for upstream emissions from electricity in a way that deviates from guidance in the GHG Protocol. Technical guidance requires that Stanford account for upstream emissions from all grid electricity it consumes—despite the fact that we are also putting electricity onto the grid from our solar facilities. However, we believe a more reasonable way to account for upstream emissions from electricity is to take into account the annualized life cycle emissions from the solar panels at our solar facilities. In 2019, Stanford's solar production from the Stanford Solar Generating Station 1 (SSGS1) and on-site renewables equated to 58% of its total electricity. Via Stanford's custom approach, we are taking responsibility for all upstream emissions from those solar panels, plus upstream emissions from the grid for the 42% of our electricity consumption that was not yet accounted for from our university-catalyzed solar facilities. In 2022, with university-catalyzed solar facilities accounting for more than 100% of Stanford's production, we will move towards including only the upstream emissions from all solar panels (and batteries) at the solar facilities but will not account for any upstream emissions from grid electricity at that time.

The resulting boundary for data included in this category is outlined below, with deviations from guidance provided by the GHG Protocol—and conventional fuel and energy accounting—specifically indicated.

Table 1: Stanford Fuel & Energy Activities Data Boundary by Category Component

Category Component	Included in Stanford Fuel + Energy Activities	Adheres to GHG Protocol Guidance	Conventionally Included in Fuel and Energy Footprint
Upstream emissions of purchased fuels			
Stationary sources	✓	✓	✓
Mobile fleet	✓	✓	✓
Upstream emissions of purchased electricity			
Upstream emissions from grid electricity	Partial until 2022		✓
Emissions from energy provided to hospitals & other outside entities	✓	✓	✓
Life cycle emissions of solar panels	✓		
Transmission & distribution losses			

Supply chain emissions from losses	✓	✓	✓
Generation emissions from losses	✓	✓	✓

Calculation Methodology

Initial quantification of emissions in this category was completed by the Office of Sustainability prior to creation of the Scope 3 Emission Program. Program staff have collaborated with the Office of Sustainability to include summaries of that work in this paper along with more recent calculations.

For the fuel and energy activities category, there are three primary sources of emissions factors:

- **U.S. Environmental Protection Agency (EPA):** The EPA maintains the Emissions & Generation Resource Integrated Database (eGRID), which publishes annal emissions, emission rates, resource mix, grid loss rates, and other data and statistics for electricity in the United States. Data is available on national and regional grids (i.e., "Western" grid), and in some cases on subregional levels (i.e., California's grid, "CAMX") depending on the level of data aggregation available to the EPA.
- **Department of Energy National Energy Technology Laboratory (NETL):** Part of the DOE's national laboratory system, NETL focuses on applied research for clean production of and use of domestic energy resources. Specifically, NETL has expertise in fossil fuel research and has produced emissions factors for natural gas.[4]
- **The United Kingdom's Department for Environment, Food and Rural Affairs (DEFRA):** DEFRA publishes "conversion factors" on an annual basis. Its factors are sourced from original research, industry statistics, government publications, and other life cycle assessment databases. While this source is often used by multinational companies, a majority of the underlying data is European-focused, although country-specific factors are sometimes provided.
- **Comprehensive Environmental Data Archive (CEDA):** A comprehensive database specific to the United States, CEDA was designed using U.S. economic input output (EIO) data to assist in life cycle assessments, carbon footprinting, and sustainable spend analyses. The included economic data represents 380 industries and is regularly updated as new economic data is released. Among other sources, CEDA draws from the U.S. Bureau of Economic Analysis, the U.S. Energy Information Administration (EIA), the EPA and the DOE.

The sources described above are each referenced by calculation tools in unique ways. The calculation tools included in this analysis are:

- **The Sustainability Indicator Management & Analysis Platform (SIMAP):** Created by the University of New Hampshire, the SIMAP tool helps universities quantify emissions in scope 1, 2, and some scope 3 categories that are particularly applicable to higher education, including commuting, business travel & study abroad, student travel to/from home, food, paper, fuel and energy activities, and waste & wastewater. The tool is publicly available for a minor membership fee of $600 per year.
- **VitalMetrics Carbon360 Platform:** Carbon360 is a proprietary, cloud-based solution developed at the University of Santa Barbara and now owned by VitalMetrics. The tool pulls emissions factors from a combination of databases, such as CEDA, to make it simple for customers to calculate scope 1, 2, and 3 emissions across the fifteen categories defined by the GHG Protocol. This tool cost Stanford $10,000 in its first year to deploy.

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[4] Littlefield, James, Dan Augustine, Ambica Pegallapati, George G. Zaimes, Srijana Rai, Gregory Cooney, and Timothy J. Skone. "Life Cycle Analysis of Natural Gas Etraction and Power Generation." NETL. April 19, 2019. https://www.netl.doe.gov/energy-analysis/details?id=7c7809c2-49ac-4ce0-ac72-3c8f8a4d87ad

- **DEFRA & EPA calculations:** Because DEFRA and EPA emissions factors are publicly available, Scope 3 Emissions Program staff utilized these emissions factors to develop a third estimate of emissions for fuel and energy to compare to the outputs of the other two tools. Specifically, "well to tank" (WTT) emissions from fuel, which are defined as supply chain emissions, were taken from DEFRA. For electricity, the upstream activities, or WTT emission factor associated with consumed and lost power was taken from DEFRA, while EPA estimates were used for line loss rates. Finally, eGRID subregion emission factors from the EPA were used to estimate the emissions associated with generating lost power.

The Appendix discusses which emissions factors are being applied by each tool for each component of Stanford's selected boundary and highlights that the key methodology differences between tools lie in the upstream fuel and upstream electricity components. To weigh these differences, Scope 3 Emissions Program staff developed a list of fuel & energy-specific criteria on which to rate each tool. The criteria are shown below, along with their assigned weights:

- Use of U.S. specific data (35%)
- Match (or closely match) Stanford's boundary requirements (35%)
- Use by other institutions (10%)
- Emissions factor transparency (20%)

Using this weighting scheme, VitalMetrics was the clear winner, primarily because it uses U.S. specific data and has the closest match to Stanford's boundary requirements. While it takes into account all fuel and energy components presented in Table 1, the other tools are not as comprehensive: SIMAP only includes emissions from generation of T&D losses in this category and DEFRA emissions factors are not specific to the U.S. The Appendix provides further detail on the specific inputs, outputs and calculation methodologies followed by all three tools, and the benefits of VitalMetrics.

However, none of the three approaches initially considered upstream emissions from electricity in the way that we've defined it in the boundary section above. Therefore, the VitalMetrics results needed to be adjusted to account for this custom requirement. To do so, program staff calculated the appropriate proportion of upstream emissions from grid electricity consistent with the 42% of Stanford electricity consumption that is not matched with renewable energy inputs onto the grid, and upstream emissions from solar were added in, as discussed below. It is worth noting that VitalMetrics assisted with the process of tabulating life cycle emissions from solar and is willing to customize its methodology to precisely match Stanford's approach moving forward.

Incorporating Life Cycle Emissions of Solar Panels

Conventionally, the emissions associated with extraction, manufacturing and transportation of solar panels would be included in the Purchased Goods & Services scope 3 emissions category. However, because Stanford has entered power purchase agreements for its two solar facilities, we do not purchase the panels outright and therefore the emissions associated with those panels may not technically belong in the Purchased Goods & Services category either. Because of this discrepancy, we felt that adding the life cycle emissions of solar panels in the Fuel and Energy category as a substitute for upstream emissions from electricity taken from the grid (which is matched by Stanford's renewable inputs onto the grid) was the fairest way to incorporate them.

To tabulate these emissions, a study performed by NREL[5] was sourced by VitalMetrics staff that harmonized studies of life cycle emissions from solar panels. Published results from 400 studies of PV systems were reviewed and screened; seventeen studies passed the screening, which provided 46 estimates of life cycle emissions per kWh for solar panels. This particular study found that of all the harmonization factors taken into account, the influence of solar irradiation was the strongest.

To take this one step further, Alex Evers, a Scope 3 Emissions Program intern, evaluated the underlying studies directly that had been included in the NREL harmonization. One study in particular included a solar irradiation factor for the southwest United States, and matched other known parameters for Stanford's solar panels, such as mount type, module efficiency, estimated lifetime, and degradation efficiency (some important parameters, such as type of panel, remain unknown).[6] This study reported life cycle emissions of 20 kg CO2e/kWh. Based on this metric and the annual production of SSGS1 and Stanford's on-site solar panels, Scope 3 Emissions Program staff estimate life cycle emissions from Stanford's solar panels to be 3,003 MTCO2e in 2019. These will increase to an estimated 6,316 MTCO2e in the 2023 emissions inventory due to the launch of SSGS2.

As a final step, program staff compared these life cycle solar emissions to estimated life cycle emissions from the California grid using the Western grid electricity emissions factor of 0.4532 lbs CO2/MWh that applies to scope 2 emissions from generation and T&D. When scope 3 emissions factors for upstream electricity are incorporated (to account for the entire life cycle of the electricity), we get a value of .95 lbs CO2e/kWh. We can compare this to the value of 20 grams of CO2e/kWh discussed above for life cycle emissions from solar panels and see that the California grid—one of the cleanest grids in the world—still has a life cycle emissions output that is 21.6 times that of solar panels alone.

Future Changes

Figure 1 in the Executive Summary shows that using the VitalMetrics approach, the largest contributors to scope 3 emissions for fuel and energy activities at Stanford in 2019 were natural gas and electricity. At Stanford, there are two independent use cases for natural gas. The first is natural gas used at the Central Energy Facility, which fuels the back-up hot water generators on the coldest days of the year, when campus demand for hot water is higher than that which can be produced by the heat recovery chillers, which are powered by electricity and simultaneously produce hot water and cold water for building heating and cooling. This natural gas use comprises 27% of Stanford's scope 3 emissions in this category. Studies are currently underway to help the Central Energy Facility wean off this natural gas use; for example, lake water heat exchange would allow the transfer of heat from the lake water that comprises Stanford's non-potable water system to the hot water used for building heating, reducing the need for the back-up hot water generators and the natural gas that fuels them. It is likely that both scope 1 and scope 3 emissions associated with this natural gas source will be reduced—if not eliminated—within the next decade as the Central Energy Facility pursues complete electrification.

On the other hand, the other category of natural gas use at Stanford is that used for cooking, water heating, laundry, research, and/or heating (for buildings not connected to the Central Energy Facility) in distributed buildings

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[5] https://www.nrel.gov/docs/fy13osti/56487.pdf

[6] Kim, H.; Fthenakis, V.; Choi, J.; Turney, D. (2012). "Life Cycle Greenhouse Gas Emissions of Thin-film Photovoltaic Electricity Generation Systematic Review and Harmonization." *Journal of Industrial Ecology* (16:S1); pp.S110-S121.

throughout the main campus and at Stanford's satellite campuses. This natural gas use comprises 31% of Stanford's scope 3 emissions in this category. While there is a clear path to building-level electrification for newly constructed facilities (especially for non-laboratory buildings), retrofitting older buildings to be fully electric is a time-intensive and expensive task. Electrification of these distributed natural gas sources is currently being studied by the Department of Sustainability & Energy Management (SEM). At the least, the natural gas equipment in these buildings can be replaced with electric alternatives as it is upgraded at the end of its useful life. With these electrification projects being conducted in a gradual manner, it is likely that this source of natural gas use—and the scope 1 and scope 3 emissions associated with it—will steadily decline to zero by roughly 2040.

Emissions associated with electricity line losses comprise another 24% of emissions in this category. In 2019, upstream emissions from grid electricity comprised15%; that number will fall to zero with the launch of SSGS2. On the other hand, annual life cycle emissions from solar contribute another 13% to scope 3 emissions in this category in 2019, which will essentially double with the launch of SSGS2. It is worth noting that SSGS2 currently produces more electricity than the university consumes; as the university's electricity use increases due to campus growth and comes closer to matching total solar output, these annual emissions from solar panels will remain relatively constant, rather than increasing (as they would in the alternative scenario).

The university receives Renewable Energy Credits (RECs) for the renewable energy generated at its solar facilities that are retired to reflect the university's commitment to renewables. However, some RECs are bought and sold each year to allow the RECs retired to exactly match the university's annual electricity consumption. One possible way to mitigate scope 3 emissions from electricity would be to include these scope 3 emissions in the annual REC accounting process. Finally, efficiency programs are another key factor in reducing the scope 3 emissions associated with electricity consumption; luckily, SEM manages robust energy efficiency programs that help reduce these emissions.

Conclusion

Scope 3 emissions from Fuel and Energy Activities equate to 11% of Stanford's peak scope 1 & 2 emissions in 2019, with a total of 23,723 MTCO2e. While the conventional approach would not have accounted for the upstream impacts—positive or negative—of Stanford's significant renewable energy investments, the customized approach included in this paper presents an alternative methodology that aligns with university priorities. Using this approach, 46% of Stanford's scope 3 emissions from fuel and energy are associated with natural gas. These are expected to reach zero by 2040 based on existing university programs. Another 52% of Stanford's emissions in this category derive from electricity use, which will be influenced and eventually significantly decreased by the launch of SSGS2. Thus, the university is already headed in the right direction to decrease and potentially fully eliminate scope 3 emissions from fuel and energy by 2050. While the Scope 3 Emissions Program will continue to quantify these emissions on an annual basis, we do not recommend the creation of additional programs to mitigate these emissions at this time.

Appendix: Detailed Calculation Methodology

All activity data used in this category comes directly from Stanford's scope 1 and 2 emissions inventory, conducted annually by the Office of Sustainability. The total amounts of each fuel type and number of kWh purchased that inform the Scope 1 & 2 emissions inventory are used to calculate their corresponding scope 3 footprint. The total volume of fuels purchased inform the university's scope 1 footprint, and the total number of kwh purchased inform the university's scope 2 footprint.

The Executive Summary includes a complete definition of the three sub-components of the Fuel and Energy Activities category: upstream emissions from fuel, upstream emissions from electricity, and electric grid losses, as well as a description of Stanford's custom approach. Please note that emissions from upstream activities for both fuel and electricity are often referred to as either supply chain emissions or "well to tank" (WTT) emissions; these terms are used interchangeably below.

Tool Comparison

Table 2 illustrates the components calculated by each tool and the source of emissions factors used for each component. It is clear from Table 2 that VitalMetrics uses the most sophisticated combination of databases to source the emissions factors that are most applicable to Stanford. On the other hand, VitalMetrics does also have some minor drawbacks. To weigh these pros and cons, a basic ranking scheme was applied to the three tools, whereby each tool was evaluated on a set of four attributes that vary in weight, with use of U.S. specific data and ability to meet Stanford's boundary requirements as the most important and use by other institutions and emissions factor transparency as less important. For each criterion, each tool was assigned a binary score of 1 or 0, based on whether it meets that criterion. The respective weights, points, and total scores for each tool are shown in Table 3, with VitalMetrics achieving the highest total score.

Table 2: Emissions Factor Databases referenced by Calculation Tools

Category Component	SIMAP	VitalMetrics	DEFRA & EPA (publicly available)
Upstream emissions of purchased fuels			
Stationary sources	N/A	EPA (diesel), NETL (natural gas), CEDA (propane)	DEFRA
Mobile fleet	N/A	EPA	DEFRA
Upstream emissions of purchased electricity			
Upstream emissions from grid electricity	N/A	EPA (eGRID subregions), CEDA (Stanford energy system)	EPA (eGRID subregions), DEFRA
Emissions from energy provided to hospitals & other outside entities	N/A	CEDA	EPA, DEFRA
Life cycle emissions of solar panels	N/A	NREL	Journal of Industrial Ecology
Transmission & distribution losses			
Well to tank emissions from losses	EPA	EPA (eGRID subregion losses), CEDA (upstream emissions)	EPA (eGRID subregion losses), DEFRA (upstream emissions)

Generation emissions from losses	EPA	EPA (eGRID subregion losses), CEDA (generation emissions)	EPA (eGRID subregion losses & upstream emissions)

Table 3: Weighting Scheme for Calculation Tool Selection

Tool	Total Emissions (MTCO2e)	Uses U.S. specific data	Meets Stanford's boundary requirements	Used commonly by other institutions	Emissions factor transparency	Score
Weight (%)	-	35	35	10	20	100
DEFRA/EPA	46,094	0	0	1	1	30
SIMAP	3,761	1	0	0	1	55
VitalMetrics	25,555	1	1	0	0	70

Table 3 also illustrates in the second column the wide range in total emissions produced by the various tools. For SIMAP, the emissions are relatively small because the boundary is small; SIMAP only includes emissions from generation of T&D losses in this category. On the other hand, the DEFRA emissions are relatively large, likely due to the lack of specificity of the DEFRA emissions factors to the U.S. In particular, the emissions factors employed by DEFRA for upstream emissions from fuel are much smaller than those calculated by VitalMetrics, while the emissions factors for upstream emissions from electricity are much larger. This makes sense since the California grid is quite clean compared to others around the world. Some methodological differences between tools also influence these results, as discussed in the sections below.

Based on these results, Scope 3 Emissions Program staff recommend VitalMetrics as the best calculation tool for the Fuel and Energy Activities category, with an emissions total for calendar year 2019 of 25,555 MTCO2e. This total has been further refined, as described in the body of the paper, to subtract out the proportion of Stanford's upstream emissions from grid electricity that are matched with our solar input onto the grid, as well add the life cycle emissions from our solar panels, resulting in a final total of 23,723 MTCO2e.

It is worth noting that because the EPA and NETL emissions factors utilized by VitalMetrics are publicly available, the only proprietary emissions factors in use by VitalMetrics are those in the CEDA database.

Upstream Emissions from Fuels

Tool Inputs

For upstream emissions from fuel directly combusted by the university, the exact fuel type informs the emissions footprint. The fuel types and quantities of each used at Stanford in calendar year 2019 are illustrated in Table 4. These inputs were used for each of the three calculation approaches described below.

Table 4: Inputs for Annual Consumption of Fuels by Fuel Type

Fuel	Quantity	Unit

Diesel	1,616	mmBTU
Gasoline	135,231	gal
Natural Gas	512,937	mmBTU
Biodiesel (B5)	1,589	gal
Propane[7]	5	gal

DEFRA

DEFRA emissions factors from 2019 were used to calculate the upstream emissions associated with all fuels.[8] The selected emissions factors for Stanford's analysis are listed in Table 5 below.

Table 5: DEFRA Emissions Factors for Upstream Emissions from Fuels

Fuel	DEFRA Fuel Category	DEFRA Fuel Name	Emission Factor (kg CO2e)	Unit
Diesel	Liquid fuels	Diesel (average biofuel blend)	0.617	liters
Natural Gas	Gaseous fuels	Natural Gas	0.264	cubic meters
Gasoline	Liquid fuels	Petrol (Average Biofuel Blend)	0.598	liters
Biodiesel (B5)	Liquid fuels/Biofuels	Biodiesel	0.367	liters
Propane	Gaseous fuels	LPG	0.191	liters

DEFRA's emission factors related to fuel come from two papers. For upstream emission factors relating to diesel, petrol, kerosene, natural gas, CNG, and LNG, data are taken from a study by Exergia.[9] This paper from Exergia includes detailed modelling of upstream emissions associated with 35 crude oils used in EU refining (which accounted for 88% of the EU's imported oil in 2012), estimates of the emissions associated with transport of these crude oils to EU refineries by sea and pipeline based on location of ports and refineries, and emissions from refining, which were modelled on a country-by-country basis based on the specific refinery types in each country. An EU average is then calculated based on the proportion of each crude oil going to each refinery type. Upstream emissions for coal, naphtha, and LPG come from the "JRC Well-To-Wheels" 2014 study, since Exergia's study does not include these fuels.[10]

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[7] The propane gallon amount was estimated using a receipt for propane purchase of $177.25. Using online estimates for liquefied propane volume by weight, as published by the Alaskan government, there are around 4.22 pounds per gallon of liquefied propane, which equates to Stanford consumption of 4.73 gallons in CY19.

[8] DEFRA. "Greenhouse gas reporting Conversion factors for 2019: full set (for advanced users)." https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2019. June 2019.

[9] Department for Environment, Food, and Rural Affairs (UK). "2019 Government greenhouse gas conversion factors for company reporting: Methodology paper for emission factors Final Report" August 2019. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/904215/2019-ghg-conversion-factors-methodology-v01-02.pdf

[10] Ibid.

Applying these emissions factors to the raw fuel data shown in Table 4, we calculate a total of 4,381 MTCO2e for upstream emissions from fuel using the DEFRA method.

SIMAP

SIMAP does not estimate emissions from upstream activities associated with fuel. SIMAP reports that their research on upstream energy emission factors for non-electricity sources is near conclusion and it hopes to release functionality that includes the full spectrum of upstream energy emissions factors within the year.

VitalMetrics

The VitalMetrics Carbon360 tool uses emissions factors from their proprietary CEDA database. Stanford's scope 3 emissions by fuel type produced by VitalMetrics are illustrated in Table 6 below.

Table 6: VitalMetrics Emissions for Upstream Emissions from Fuels

Category	Source	Total Emissions (MT CO2e)
Diesel	EPA	221.41
Natural Gas	DOE NETL	10,843.97
Gasoline	EPA	324.55
Biodiesel (B5)	EPA	8.28
Propane	CEDA	0.15

Using the inputs supplied in Table 4 and the emission factors in Table 6, VitalMetrics reported a total of 16,413 MTCO2e for upstream emissions from fuels.

Upstream Emissions from Electricity

Tool Inputs

Emissions for the 42% of Stanford's energy consumption that is not matched by solar inputs onto the grid were calculated by annual kWh consumption in each of the eGRID subregions displayed in Figure 3. Stanford receives electricity from three of the subregions:

- Most of Stanford's electricity is consumed from the CAMX subregion. This includes all electricity that flows through our Central Energy Facility (CEF) (both to produce heating and cooling and to power the main campus) and electricity for separate electricity accounts on our main campus and satellite campuses located in California. For accounting purposes, electricity flowing through the CEF and electricity for other electricity accounts have been separated in subsequent tables.
- Electricity used at the Stanford in Washington campus comes from the RFCE subregion
- Electricity used by offices and apartments associated with Stanford in New York comes from the NYCW subregion.

Total electricity consumed from each subregion is shown in Table 7.

Figure 3: Map of eGRID Subregions[11]

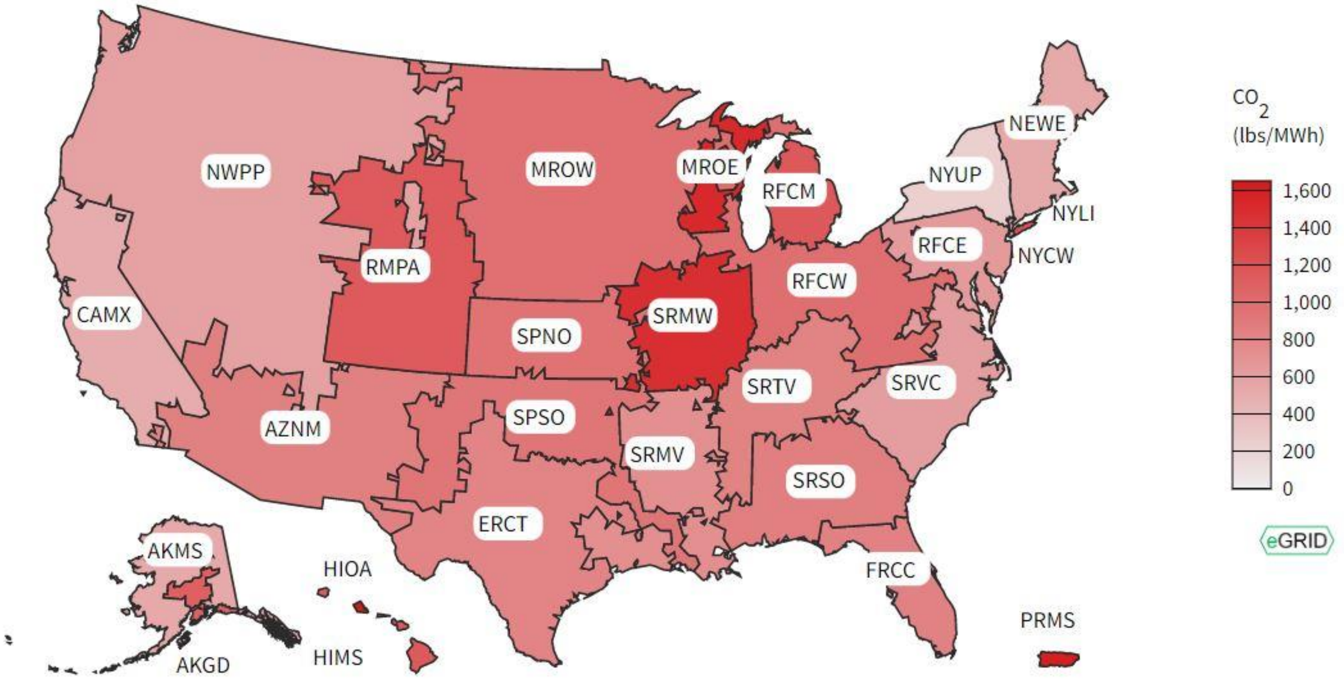

Table 7: Inputs for Annual Consumption of Electricity by eGRID Subregion

Electricity End use	eGRID Subregion	kWh
Central Energy Facility and main campus	CAMX	278,678,018
Other electricity accounts (main campus and satellite campuses)	CAMX	49,690,560
Stanford in Washington	RFCE	707,407
Stanford in New York	NYCW	113,447

DEFRA

DEFRA uses the WTT emissions factors for each kind of fuel in the UK and the total fuel consumption by type of generation for the UK. Since that information was not available for other countries, the indirect/WTT emission factors for different countries

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[11] Map sourced from EPA eGRID Power Profiler Website. https://www.epa.gov/egrid/power-profiler#/. Updated January 2022.

were estimated as being "roughly a similar ratio of the direct CO2 emission factors as for the UK (which is 14.9%)."[12] Using this methodology, DEFRA calculates a U.S. specific emissions factor of 0.071 kg CO2e/kWh.

Applying this emissions factor to the electricity inputs in Table 7, the upstream emissions from consumed electricity are estimated at 36,792.14 MTCO2e using the DEFRA methodology.

SIMAP

SIMAP does not account for upstream emissions from electricity.

VitalMetrics

VitalMetrics aggregated upstream emissions from electricity and emissions from electric grid losses in their reporting and provided the outputs listed in Table 8, which together amount to 14,156 MTCO2e. The upstream emissions from electricity are based on data from the most recent version of CEDA released in 2018 and applied to Stanford's scope 2 emissions. While these two sub-categories of emissions are officially reported together, VitalMetrics did disclose that upstream emissions from electricity are equal to "11-12% of Scope 2 emissions," which would result in approximately 8,569 MTCO2e, with the breakdown illustrated in Table 9. A factor of 42% was applied to this total to account only for upstream emissions from grid electricity that is not matched by solar inputs onto the grid to arrive at the final calculated number used in the body of the paper.

Table 8: VitalMetrics Combined Emissions from Upstream Electricity and T&D Losses

Source	eGRID Subregion	Activity Data (Inputs): Location-based Scope 2 Emissions (MT CO2e)	Total Emissions (MT CO2e)
Central Energy Facility and main campus	CAMX	63,015	11,973
Other electricity accounts (main campus and satellite campuses)	CAMX	11,282	2,143
Stanford in Washington	RFCE	30	6
Stanford in New York	NYCW	185	35

Table 9: Estimated VitalMetrics Upstream Emissions from Electricity Only

Source	Calculated Well-to-tank Emissions (MTCO2e)
Central Energy Facility and main campus	7,247
Other electricity accounts (main campus and satellite campuses)	1,297
Stanford in Washington	3
Stanford in New York	21

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[12] Department for Environment, Food, and Rural Affairs (UK). "2019 Government greenhouse gas conversion factors for company reporting: Methodology paper for emission factors Final Report" August 2019. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/904215/2019-ghg-conversion-factors-methodology-v01-02.pdf

Emissions from T&D Losses:

This category includes both the supply chain emissions of T&D losses and the emissions from generation of T&D losses. It uses the same data inputs as the prior category, shown in Table 7.

Publicly available data from DEFRA & EPA

To develop an internal estimate of T&D losses using publicly available emission factors, the Scope 3 team used EPA data to estimate the volume of line losses for which well-to-tank and generation emissions were to be calculated. The rate at which energy is lost in the process of supplying electricity to consumers is commonly referred to as the grid gross loss (GGL). Table 10 below shows the GGL for regional grids from which Stanford consumes power.

To estimate the electricity lost during transmission and distribution, the EPA recommends multiplying the distributed output (electricity used) by the loss factor, which is calculated using GGL/(1-GGL). This value is shown in the "Loss Factor" column in Table 10 below. GGL rates are published by the EPA for the United States as a whole, and for specific grid regions (i.e. "Western," "Eastern," "Hawaii," "Alaska," "ERCOT"). GGL rates are not published at the eGRID subregion level (i.e., CAMX, NYCW, RFCE). The Stanford Scope 3 team chose to use the regional GGL rates published in order to estimate GGL, since these were the most localized options available.

Table 10: EPA Grid Gross Loss Rates as % of Consumption by Grid Region

Grid Region	Grid Gross Loss (GGL)	Loss Factor: (T&D loss factor / (1 – T&D loss factor))
Western	0.051	0.054
Eastern	0.054	0.057

To estimate the kWh lost in generation, electricity consumption in each eGRID subregion was multiplied by its respective loss factor. The result of this calculation is shown in Table 11.

Table 11: Estimated line losses & emissions from generation

eGRID Subregion	Grid Region	kWh consumption	Estimated Line Losses (kWh)
Central Energy Facility and main campus	Western	278,678,018	14,976,374
Other electricity accounts (main campus and satellite campuses)	Western	49,690,560	2,670,409
Stanford in Washington	Eastern	707,407	40,381
Stanford in New York	Eastern	113,446.50	6,476

EPA eGRID subregion emission factors for 2019 were used to estimate emissions associated with generating the volume of power lost, as shown in Table 11. These emission factors can be found in Table 12 and were applied to electricity consumption in each eGRID subregion.

Table 12: EPA Emissions factors by eGRID Subregion

Region	CO2e Emission Rate (lb/MWh)
CAMX	455.251
RFCE	555.056

NYCW	698.485

To estimate the WTT emissions associated with lost power, the same WTT emissions factor of 0.071kg CO2e/kWh was used as for directly consumed power in the prior section. Emissions for WTT and generation of T&D losses can be found in Table 13 using the estimated line losses shown in Table 11.

Table 13: Emissions Associated Lost Electricity

eGRID Subregion	Grid Region	Emissions per region from generation of losses (MT CO2e)	Emissions per region from WTT of losses (DEFRA)
Central Energy Facility and main campus	Western	3,093	1,068
Other electricity accounts (main campus and satellite campuses)	Western	551	191
Stanford in Washington	Eastern	13	3
Stanford in New York	Eastern	2	0.5

The above line loss rates and generation emission factors from the EPA, along with the WTT emission factors from DEFRA for electricity generation total to 4,921 MT CO2e, with 1,262 MT CO2e from upstream activities, and 3,659 MT CO2e from T&D losses.

SIMAP

The T&D loss calculation in SIMAP is based on Scope 2 emissions rather than energy consumption and adjusted using the same loss factor methodology as recommended by the EPA, which can be found in Table 11:

T&D loss emissions = Scope 2 purchased electricity emissions * (T&D loss factor / (1-T&D loss factor))

SIMAP's methodology uses location-based Scope 2 emissions as an input, which were 74,518 MTCO2e in 2019. The resulting emissions from SIMAP's calculations for emissions associated with T&D losses is 3,761 MTCO2e.

VitalMetrics

As mentioned previously, VitalMetrics aggregated upstream emissions from electricity and emissions from electric grid losses in their reporting and provided the outputs listed in Table 8. The emissions from T&D losses are localized and sourced from the EPA, using roughly the same methodology and data illustrated in Tables 10-12. While these two sub-categories of emissions are officially reported together, we can ascertain from the information provided from VitalMetrics that emissions from T&D losses would equate to approximately 5,588 MTCO2e, with the breakdown illustrated in Table 14.

Table 14: VitalMetrics Carbon 360 Calculation Methodology & Emissions by Source

Source	Transmission & Distribution Emissions (MT CO2e)
Central Energy Facility and main campus	4,726
Other electricity accounts (main campus and satellite campuses)	846
Stanford in Washington	2
Stanford in New York	14

Results

Table 15: Emissions subtotals for each methodology by source

Method	Upstream Emissions from Fuel	Upstream Emissions from Electricity	Emissions from T&D Losses	Total Emissions from Fuel & Energy Related Activities
SIMAP	N/A	N/A	3,761	3,761
Vital Metrics	11,398	8,569	5,588	25,555
EPA/DEFRA	4,381	36,792	4,921	46,094

As explored in the body of the paper, Scope 3 Emissions Program staff believe VitalMetrics' use of U.S. specific data and ability to meet Stanford's boundary requirements make it the most applicable and credible option. Based on these results, Scope 3 Program staff recommend VitalMetrics as the best calculation tool for the Fuel and Energy Activities category at Stanford, with an emissions total for calendar year 2019 of 23,723 MTCO2e. The breakdown by fuel/energy category is shown in Table 15.

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