GHG EMISSIONS INVENTORY AT USU

To assess the impact an organization imposes on the climate, a thorough evaluation of its carbon footprint is necessary. A greenhouse gas (GHG) emissions inventory identifies, quantifies, and categorizes sources of GHG emissions. Furthermore, a GHG inventory is essential to a legitimate GHG reduction strategy and it reinforces an organization's commitment to addressing climate change. Recognizing this, USU became signatory to the American College & University Presidents Climate Commitment on January 22nd, 2007. The commitment requires the University to develop and implement strategies to reduce GHG emissions.

The inventory is primarily designed to allow the University to establish a GHG emissions baseline. The goal of the inventory is to account for all the emissions generated by the University and to set targets for reductions below the base year emissions. The inventory focused on scope I, II and several significant scope III emissions (see Box 1) as defined by the World Resources Institute (2004).[i] Scope III emissions, (i.e., commuting, air travel, refrigerants and solid

Box 1 - Scope & Emissions Sources

The Concept of Emissions "Scope"

According to the World Resources Institute (2004), three scopes (Scope I, Scope II, and Scope III) are defined for greenhouse gas (GHG) accounting and reporting purposes. Scopes I and II are carefully defined by WRI and WBCSD's Greenhouse Gas Protocol to ensure that two or more organizations will not account for emissions in the same scope.

The Greenhouse Gas Protocol requires organizations to separately account for and report on Scopes I and II at a minimum. The scopes are defined as follows:

Scope I: Direct GHG emissions:
Direct GHG emissions occur from sources that are owned or controlled by the organization. For example, emissions from combustion in owned or controlled boilers, furnaces, vehicles, etc.

Scope II: Electricity indirect GHG emissions:
This encompasses GHG emissions from the generation of purchased electricity consumed by the organization. Scope II emissions physically occur at the facility where electricity is generated, not at the end user site.

Scope III: Other indirect GHG emissions:
This is an optional reporting category under the Greenhouse Gas Protocol that allows for the inclusion of all other indirect emissions. Scope III emissions are a consequence of the activities of the organization, but occur from sources not owned or controlled by the organization. Some examples include extraction and production of purchased materials, and use of sold products and services.

waste), introduced data measurement issues with regard to the inventory calculation, but we added value by broadly representing the GHG emissions over which the University has some control. Also, it has helped us to identify areas where data management can be improved.

Scope & Emissions Sources

The first step in planning an inventory is defining the organizational and operational boundaries (World Resources Institute, 2002).[ii] For the purposes of this inventory, USU is defined as an organization which includes teaching and research buildings funded by the state and student-fee-funded buildings (e.g., Health, Physical Recreation Education Center, University Student Center), University owned farms and other USU owned or managed off-campus locations primarily associated with the University Regional Campus and Distance Education (RCDE) program. Other locations, such as University Extensions, were omitted primarily due to the lack of data, as these operations generally consist of leased space from county governments in the state of Utah. The operational boundaries – otherwise known as USU Scope I, II, and III GHG emissions – include emissions from natural gas-fired boilers, the University fleet, purchased electricity, plus escapee emissions of HCFCs from cooling units, emissions associated with University owned farm animals, faculty, student, and staff commuting in individual-owned vehicles, air travel for University-related business, and landfill emissions caused by University-generated waste. The *operational boundary* does not include business travel in non-university owned cars or supply chain production of materials (e.g., paper), equipment (e.g., computers), or infrastructure (e.g., building materials) used on campus. In setting the operational boundary, we tried to follow the principles outlined by the

Figure 1: Emissions Sources Considered in the GHG Inventory

Emission Source	Scope	Included in Inventory
Natural Gas Use	I	Yes
University Fleet	I	Yes
Coolant	I	Yes
Produced Electricity	I	Yes
Farm Animals	I	Yes
Farm Fertilizer	I	Yes
Purchased Electricity	II	Yes
Air Travel	III	Yes
Solid Waste	III	Yes
Commuting in Individual Owned Vehicles	III	No

GHG Protocol (2004)[iii] – relevance, completeness, consistency, transparency, and accuracy – but were ultimately largely influenced by the availability of data of reasonable quality (i.e., what USU was already measuring, or what could be estimated from something that USU was measuring). Finally, our inventory considers the six Kyoto gases[1] and R-22[2], an HCFC used in some on-campus HVAC systems. Figure 1 summarizes this information, identifying GHG emissions sources by scope and by whether it is included in the GHG inventory.

Methodology & Data Sources

We used the Greenhouse Gas Inventory Calculator (volume 5.0),[iv] developed by Clean Air – Cool Planet (CA-CP) specifically for universities, to generate a GHG inventory for USU. Using the CA-CP Calculator, activity data (e.g., therms of natural gas, kilowatt hours of electricity, number of commuters, miles of air travel) are multiplied by an emissions factor (e.g., kg CO_2/kWh, kg CH_4/kWh) to yield emissions for each activity by specific type of greenhouse gas. However, each GHG has a different heat trapping potential and a different atmospheric lifetime, which results in a different global warming potential (GWP) for each GHG (see Figure 2).

Figure 2: Global Warming Potentials and Atmospheric Lifetime of several greenhouse gases

Gas	Atmospheric Lifetime (Years)	Global Warming Potential (100 Year)
Carbon Dioxide (CO_2)	50-200	1
Methane (CH_4)	9-15	21
Nitrous Oxide (N_2O)	120	310
HFC – 134A	15	1,300
HFC – 404A	>48	3,260
Sulfur Hexafluoride (SF_6)	3,200	23,900

(Source: CA-CP)

[1] Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs), Sulphur hexafluoride (SF_6)

[2] R22, also known as Chlorodifluoromethane (CHClF2), is a HCFC with a 100 year global warming potential of 1700 (IPCC, 2001c).

The CA-CP Calculator resolves this problem by converting the GHG emissions to a common unit of measurement, metric tons of carbon dioxide equivalent ($MTCO_2e$) that can be used to compare all emission sources. The following descriptions explain the major sources of GHG emissions from USU operations.

GHG Emissions Sources Included in GHG Inventory

Electricity

USU generates electricity on campus and is responsible for the GHG emissions associated with the generation of the electricity it purchases from its electricity provider.

For academic years 2006 and 2007, total electricity demand was determined from an energy use spreadsheet produced by USU's energy manager, so the data is assumed to be reliable. Total electricity demand for RCDE facilities, farms, research foundation facilities and airport operations were calculated based on monthly electricity bills, so the data is also highly accurate. Prior to 2005, there was limited data available on electricity consumption.

Once annual kWh data is entered, the CA-CP Calculator converts annual electricity consumption data into GHG emissions by region specific emissions factors for CO_2, CH_4, and N_20 and then converts these numbers into $MTCO_2e$.[3] In 2007, electricity consumption at USU was responsible for emitting **30,903 $MTCO_2e$**, roughly 26% of total emissions.

Natural Gas

USU utilizes natural gas on campus for building heating requirements, laboratory research and some fleet vehicles. Natural gas is the third largest emission source at USU, representing roughly one quarter of USU's total GHG emissions.

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[3] We chose NWGB, for an emissions factor of .686 kg CO_2 / kWh, .00000662 kg CH_4/ kWh, and .00001521 kg N_2O/ kWh (CA-CP, 2007). The CA-CP Calculator took the factors from the US EPA's Emissions and Generated Resource Integrated Database (eGRID) based on data from 2005.

For academic years 2006 and 2007, total natural gas usage was also determined from an energy use spreadsheet produced by USU's energy manager so we assume the data to be high quality and reliable. Total natural gas demand for RCDE facilities, farms, research foundation facilities and airport operations was calculated based on monthly electricity bills, and the data is highly accurate. Prior to 2005, there was limited data available on electricity consumption.

The CA-CP Calculator converts annual MMBtu natural gas use into GHG emissions by using the appropriate emissions factors for CO_2, CH_4, and N_20 and then converts these numbers into $MTCO_2e$. In 2007, natural gas consumption at USU was responsible for emitting **27,543 $MTCO_2e$**[4], roughly 23% of total emissions.

Campus Vehicle Fleet

The University fleet includes all University-owned cars and trucks, including carpool and vanpool vehicles. The campus fleet is the smallest of the three categories considered in the GHG inventory and emissions from these sources are almost negligible in comparison to electricity and natural gas related emissions.

The University fleet includes both gasoline and diesel vehicles, which are entered into the inventory separately because of their differing emissions factors. Gasoline fleet usage was provided by the Campus Fleet Business office over the 2006 and 2007 time period, and is based on fuel records maintained by the state fleet system for fuel card usage. Prior to 2006, insufficient data exists to make meaningful calculations as they relate to fleet fuel usage. The CA-CP Calculator converts the annual fuel use into GHG emissions by using the appropriate emissions factors for CO_2, CH_4, and N_2O and then converts these numbers into $MTCO_2e$. In 2007, USU fleet fuel consumption was responsible for emitting **3052 $MTCO_2e$**, roughly 3% of total emissions.

[4] The CACP Calculator uses emission factors of 52.8 kg CO_2/MMBtu, 5.3E-03 kg CH_4/MMBtu, and 1.05E-04 kg N_2O/MMBtu.

Other GHG Emissions Sources

Estimations of scope III emissions are provided from several sources. This broader scope allows us to identify potentially significant emissions sources and provide the University with a more accurate reflection of its actual climate footprint and a wider range of mitigation strategies. While some of the "other sources" have relatively small impacts, others (e.g., commuting, air travel) are potentially large GHG emissions sources; and while these emissions might not be considered USU emissions per se, the actions of the University certainly influence these emissions, and so they are relevant when considering mitigation strategies. Furthermore, including these emissions sources improves the comparability of USU's inventory with other organizations, since many of these emissions categories are being reported by universities and corporations nationwide.

Refrigeration

USU currently uses multiple refrigerants to meet cooling demands, but only R-22 is considered a GHG. USU does not currently record information on refrigerant usage on campus or escapee emissions of refrigerants. Therefore, we estimated escapee emissions of R-22 based on a collection of work orders for the 2006-07 fiscal year, which is labeled 2007 in our inventory. These work orders describe how much R-22 is added and how much was reclaimed or recycled. We assume the difference between what is added and what is taken out are the escapee emissions. In 2007, based on available work orders, the net R-22 added to the system was 523 pounds, which is recorded in the inventory as the amount of escapee emissions. Since there was only one year of available data, it was not possible to develop a trend; so, we assumed that 568 pounds were emitted in 2007. Emissions of R-22 are converted to $MTCO_2e$ in the CA-CP Calculator using an emissions factor, yielding an estimate of **560 $MTCO_2e$** for refrigerants, a fraction of 1% of USU's total GHG emissions.

Solid Waste

Waste disposal produces methane gas emissions in the decomposition of organic matter, and is a common GHG emissions category included in campus inventories. Data on USU's solid waste disposal was provided courtesy of USU Recycling Management Manager, Kevin Phillips. The University transports its waste to the Logan City Landfill for waste disposal, which measures the trash weight. Therefore, waste disposal records for the main USU campus is deemed very reliable. Data for the RCDE campuses, farms and the airport, are not readily available as commercial waste disposal services pick-up this trash and co-mingle it with other disposal customers. Using main campus data, an amount of waste per student at the main campus was calculated. Next this amount per student was applied to the RCDE campuses to estimate RCDE waste. The university farms do not generate much waste and are considered immaterial for inclusion in this category. In 2007, GHG emissions from University waste were **3049 MTCO_2e**, roughly 3% of total emissions.

Agriculture - Animals and Fertilizer

Animals produce methane gas emissions and are a common GHG emissions category included in campus inventories of agricultural universities. Methane produced during digestion, is a significant part of global emissions. As food is digested, microbes break down the organic matter creating methane by enteric fermentation. Ruminant animals, such as cows, emit an especially large amount of methane through their digestive process.[v] Data on USU's Animals was provided courtesy of the farm manager for the Animal Dairy and Veterinary Sciences Department. Exacting data on animal types and counts is maintained by the department.

A major direct source of nitrous oxide from agricultural soils is that of synthetic fertilizer use. Widespread increase in the use of such nitrogen based fertilizers has been driven by the need for greater crop yields, and by more intensive farming practices.[vi] Data on USU's fertilizer application was provided courtesy of the farm manager for the USU Agricultural Experiment Station. Exacting data on the amount of fertilizer used is maintained by the department. In 2007, GHG emissions from Agriculture were **2530 MTCO_2e**, roughly 2% of total emissions.

Transportation (non-fleet): students, faculty and staff commuting

Non-fleet transportation emissions are a result of students, staff, and faculty commuting to USU. Although these emissions belong to the individual commuters, the University has the potential to encourage alternative modes of transportation through its policy decisions and development pattern; as a result, these sources are relevant to an analysis of how USU can reduce GHG emissions. In order to calculate the GHG emissions from commuters, we estimated the total number of gallons of gasoline consumed. Since there is no easy way of calculating an accurate quantification (as is available with utility bills), the number of gallons consumed is estimated using a stream of assumptions (listed below). The CA-CP spreadsheet is set up to accept the following inputs to estimate total annual gasoline usage.

1. Number of people
2. Fuel efficiency
3. Percentage who drive alone (Single Occupancy Vehicles or SOV)
4. Percentage who carpool
5. Number of daily trips
6. Number of days completing the trip per year
7. Trip distance

This is broken up into 4 sections in the inventory: Students, Summer School Students, and Faculty & Staff. For the students section, the primary data source was the USU Office of Analysis, Assessment and Accreditation (AAA). At AAA, the Institutional Research and Planning group publishes a campus profile each year which documents total enrollment. The national averages included in the CA-CP spreadsheet were utilized to estimate fuel efficiency.

A transportation mode survey was conducted to determine the number of single occupancy vehicle (SOV) drivers, carpoolers and bus riders. Unfortunately, these data were only available for the single point in time that the survey was taken, so extrapolating a trend is not possible. It was, therefore, assumed that each year had the same mode split percentage. The USU Registrar's office was able to provide zip code information. From the zip code distances, an estimate was made from the center of the zip code to the campus of USU for each USU student.

From this process, an average commuter distance was determined to be 15.5 miles each way. The number of trips to campus per week, as well as per day, was also surveyed for each category of faculty, staff and students, and the results were weighted based upon the respective population's sizes. From this data, the amount of total fuel consumed was estimated.[5]

Finally, the CA-CP calculator converts fuel consumption to GHG emissions just as it did for USU fleet. In 2007, student commuting was responsible for approximately **20,675 MT CO_2e**, representing **10%** of total GHG emissions. Faculty/Staff commuting in 2007 was estimated using the same methods, and resulted in **12,551 MT CO_2e**, or **17%** of total emissions. The results of the inventory prove that commuting is the single largest source of GHG emissions at USU.

Air Travel

Air Travel emissions are associated with the flights of USU faculty and staff while on University-related business. In the CA-CP Calculator, the input is air miles for faculty and staff. However, USU does not have thorough documentation of all air travel from all USU faculty and administration nor students. The USU Controllers office tracks total travel costs, which can also include car rental and hotel costs. Furthermore, since travel planning is extremely decentralized, there are many ways in which people on campus can purchase and get reimbursed for travel expenses.

Estimating the miles flown

A substantial portion of USU air travel is booked through an approved state travel agency. The agencies track the travel using the departure and arrival three digit airport codes. The total air travel using state travel agencies was downloaded on to a spreadsheet (approximately 8,000 flight records) and the actual mileage for each individual flight was calculated. In order to estimate the total number of miles traveled, we did a study of travel authorizations that

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[5] Fuel Consumption = MPG / [(Total Students x % Drive Alone) + (Total Students x % Carpool)/2] x Trips/Day x Days/Year x Miles/Trip

included airfare to determine what percentage of travel authorizations used a state travel agent and what percentage booked air travel by another means, such as an online purchase. We determined that 56% of travelers used a travel agency and 44% did not. To determine total air miles for faculty and staff, we simply extended the calculated air miles for those traveling using a state agency to estimate total for each year.

Student Estimate

The university does not track student travel. However, further research provided data from other institutions that track student travel, relative to faculty and staff travel, was applied to USU. Based upon this research, it was determined that student travel is approximately 20% of faculty and staff travel and the resulting estimation was included in the inventory.

In 2007, we estimate air travel at approximately 26.4 million miles, translating into emissions of **20,505 MT CO_2e**, which represent 17% of USU's total emissions.

Current GHG Emissions

Assessment of Current USU Emissions Sources

Figure 3 displays the total GHG emissions for the most current period (2007) by emissions source. In 2007, total emissions were approximately 121,812 $MTCO_2e$.

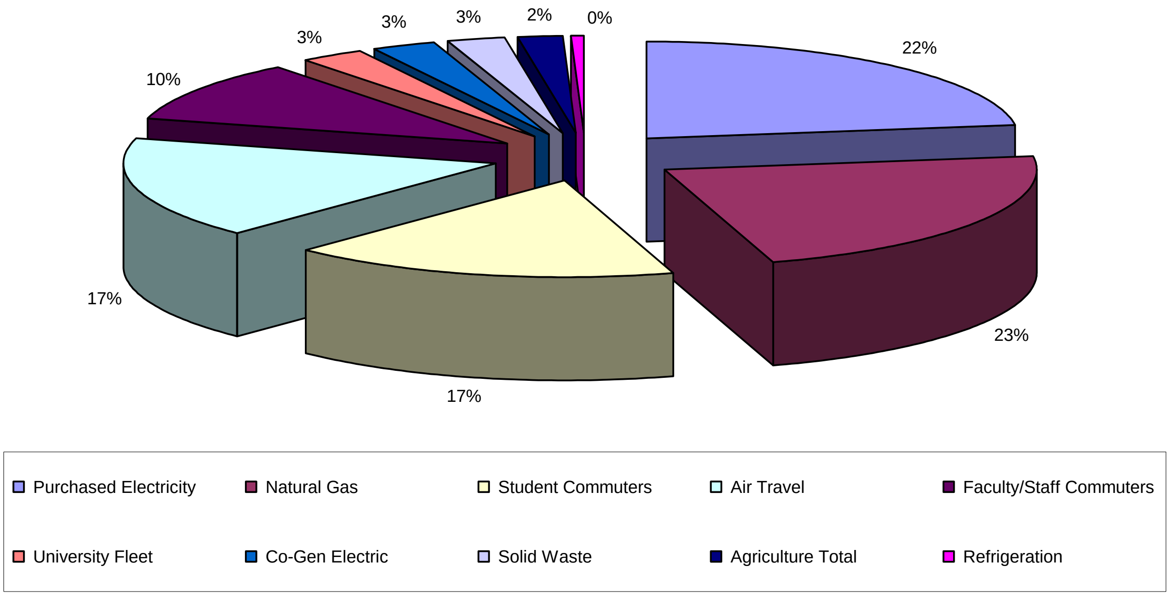
Figure 3: USU Total GHG Emissions for FY2007

	Energy Consumption MMBtu	CO2 kg	CH4 kg	N2O kg	eCO2 Metric Tonnes	Percent of Total
Purchased Electricity	313,893	27,388,960	432	992	27,693	23%
Natural Gas	531,182	27,461,024	2,780	61	27,543	23%
Co-Gen Electric	60,639	3,201,217	320	6	3,210	3%
Total Stationary Sources	591,821	30,662,241	3,100	67	30,753	25%
University Fleet	52,473	3,436,448	673	168	3,502	3%
Student Commuters	287,008	20,194,788	3,821	1,325	20,675	17%
Faculty/Staff Commuters	174,388	12,247,776	2,423	835	12,551	10%
Air Travel	103,997	20,432,263	201	231	20,505	17%
Total Transportation	617,866	56,311,275	7,119	2,559	57,233	47%
Agriculture Total	-	-	83,960	2,025	2,530	2%
Solid Waste	-	-	132,574	-	3,049	3%
Refrigeration					560	0%
Total	1,523,580	114,362,476	227,184	5,644	121,818	100%
Offsets						
Composting					(6)	
Total					121,812	

The majority of the emissions were from travel, electricity and natural gas consumption (Figure 4). To give some perspective, this is approximately the amount of GHG emitted by 20,720 cars per year.[6]

[6] For one car = 15,000 miles/year * 0.045 gallons/mile * 0.00871 $MTCO_2e$/gallon = 5.88 $MTCO_2e$/year 121,812 $MTCO_2e$ / 5.88 $MTCO_2e$ = 20,720 cars

Figure 4: Total USU GHG Emissions by Source



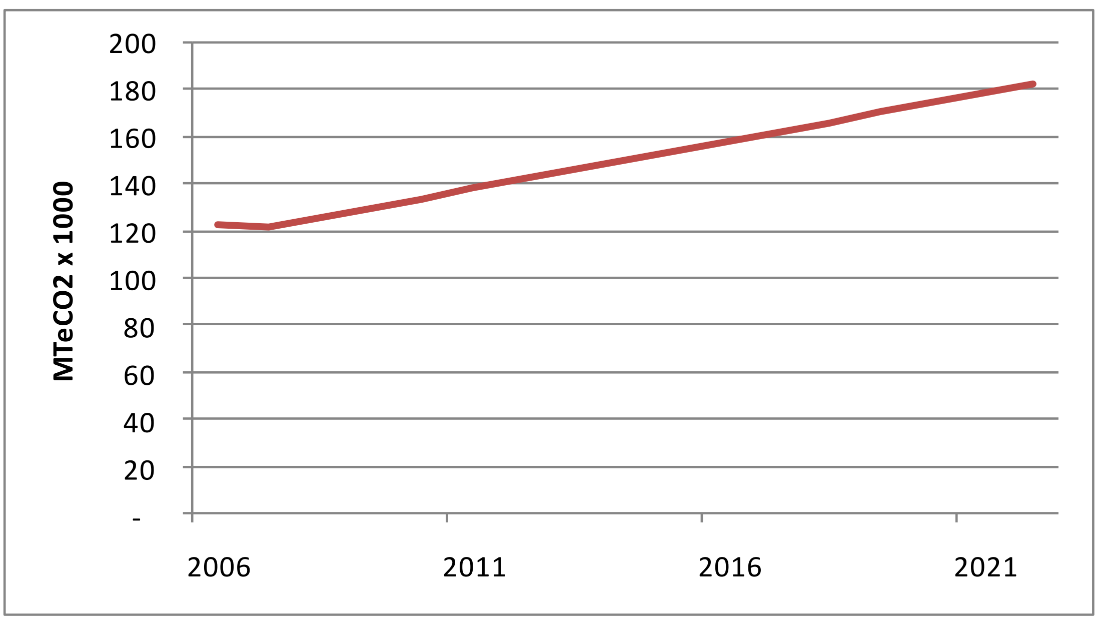
The results of the inventory suggest that the largest opportunities for GHG emissions reductions are likely to be related to electricity and natural gas consumption. However, the relatively large size of these "other" emissions – commuting and air travel, in particular – suggests that the USU does have the potential to reduce GHG emissions significantly through strategies that address these categories of emissions as well.

Campus Growth Projections

According to the Office of Campus Planning and Design, the long range development plan for the University is to grow from the current population of students to 26,000 FTE's.[vii] Using this information, we can project campus emissions as well. Emissions divided by total number of students for each year, illustrates that this intensity index is about 6.6 $MTCO_2e$ per student for the past 2 years. Although the GHG emissions per student intensity has shown a decreasing trend in the past year, several new buildings are being constructed, which will increase energy consumption on campus significantly. USU's projected growth, however, is not likely to differ significantly from its current academic profile (it is likely to continue to grow in both the sciences and the humanities).[7] As a result of these two facts – the stability of the intensity metric over the last 2 years and the knowledge about the balanced nature of projected campus growth – the intensity metric (total GHG emissions/total students) can reasonably be utilized to project a business as usual scenario for USU's GHG emissions into the future.

Utilizing the intensity index, we assume that each of the 625 new students per year will increase USU's GHG emissions by 6.5 $MTCO_2e$ annually, totaling 4,062 $MTCO_2e$ per year. We utilize this projection (Figure 5) as a baseline from which we can quantify the emissions reductions that would be required to meet particular reductions targets through 2022 (displayed in Figure 5 as the vertical distance between any target line and the projected campus emissions line for any particular year). We chose a fifteen year time horizon for our analysis because it conforms well to the University's planning horizon.

Figure 5: Unmitigated Projected Campus Emissions Growth



[7] Science buildings tend to be much more energy intensive than Humanities buildings, so if USU's projected growth was likely going to be targeted towards the sciences, this would have implications for the growth in GHG emissions through time and would make our use of the current intensity index (GHG emissions/student) less reliable.

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