Statewide Gas Emerging Technologies Program
2023 Annual Research Plan – V1.0

Background

In 2019, the California Energy Commission (CEC) released the California Energy Efficiency Action Plan (EE Action Plan) which is the state's "roadmap for an energy-efficient and low-carbon future for buildings. Energy efficiency is a key piece of California's efforts to lessen the impacts of climate change."[i] The EE Action Plan was prepared in response to legislative actions to double energy efficiency savings in electricity and natural gas end uses relative to a 2015 baseline by January 2030 (SB 350). Based on the CEC's assessment, California is expected to fall 28 percent short of the 2030 natural gas savings goal.

Technology plays a distinct role in the energy efficiency landscape as greater adoption of higher efficient equipment will help close the natural gas savings shortfall. The Statewide Gas Emerging Technology (GET) Program is the primary vehicle to identify and prioritize technology research efforts. Through GET, emerging and/or underutilized technologies are evaluated to better understand their operating characteristics, efficiency performance, market barriers, etc. with the goal of moving promising technologies up the market adoption curve thus increasing their prevalence in the market.

California is actively looking at ways to decarbonize the "gas grid" to meet California state's carbon neutrality goal. A step in this process is the introduction of hydrogen into the existing gas pipeline network. The expectation is that the future gas needs will be satisfied using a low percentage hydrogen blend that does not compromise pipeline safety and that end-use equipment will still meet efficiency performance expectations with these blended fuels. However, the impacts on both existing and new equipment need to be quantified to better understand operating characteristics.

Concurrent with the adoption of new technologies, is the need to understand market barriers, including those that are the result of the new technology, as well as any that already exist for current similar technologies. Because these technologies, even the emerging ones, are in many cases competing against electric technologies that are being deployed for electrification, understanding the differences between the electric and gas technologies, including the differences in source greenhouse gas (GHG) generation and site indoor air quality (IAQ) issues, becomes more critical than comparing single fuel technologies. Over the course of 2022 project activities, it was found that other local and statewide regulations on emissions affect the availability of emerging gas-fired technologies (e.g., Air Quality Management District regulations on NOx, California Air Resources Board regulations on emissions, local "gas-bans" etc...). The impacts of these regulations on emerging technologies evaluated through GET need to be considered.

In 2022, in addition to the ongoing discussions on electrification and decarbonization, there were two significant policy directions that could significantly impact the future of natural gas-fired space and water heating technologies in California:

- In July, the California Public Utilities Commission (CPUC) released a staff proposal related to the potential phase out of natural gas incentives in EE programs that would occur in stages from 2024 to 2028. At this point the CPUC is gathering public input for this proposal.

- In September, the California Air Resources Board (CARB) approved the "Proposed 2022 State Strategy for the State Implementation Plan" that will set a zero-emission standard for space and water heaters to go into effect in 2030[1]. It is unclear if zero emissions include CO_2 but probably

[1] https://ww2.arb.ca.gov/sites/default/files/2022-08/2022_State_SIP_Strategy.pdf

include NOx at a minimum. While this plan was voted on and approved by CARB, the details have not yet been determined. Also, it was found during the 2022 research that existing Air Quality Management District (AQMD) regulations requiring Ultra-Low NOx emissions on water heaters impact participation of storage water heaters in EE programs.

- Updates to 2022 Title 24 (effective January 1, 2023) include mandatory requirements for gas-fired water heating and space heating systems in single family homes to be ready for replacement of those systems with electric heat pump systems by adding additional space requirements and/or electrical service near the existing gas-fired water heaters/space heaters. Additionally, California climate zones 3, 4, 13, and 14 are prescriptively required to use a heat pump system for space heating or use the performance approach, and in all California climate zones a heat pump water heater must be used or the performance approach must be used (with exceptions for climate zones 3, 4,13, and 14).[2] The code notes "heat pump", which likely implies electric heat pump, but it is unclear if a gas heat pump would meet these requirements.

The 2023 Annual Research Plan sets forth the priority technology areas that will be investigated in 2023. These areas were selected to align with California's strategic goals and focus on the end-uses and customer segments that offer the greatest potential for energy savings. As with the prior research plan, there are certain programmatic limits to research areas. The following areas are not in scope for GET:

- Net power generation
- The utility side of the meter ("In front of the meter")
- Early R&D (typically less than TRL 4)
- Projects that do not save therms or do not help overcome barriers to saving therms
- Technologies that use non-IOU supplied gas (i.e., propane)

Natural gas usage across the three gas Investor-Owned Utilities (IOUs) – Pacific Gas and Electric (PG&E), San Diego Gas and Electric (SDG&E) and Southern California Gas Company (SoCalGas) – varies widely. For example, more than 60 percent of gas usage in PG&E territory occurs within the industrial customer base while industrial customers in SDG&E territory only account for 5 percent of gas usage. Table 1 shows gas usage by customer segment for each IOU[3].

Table 1. Natural Gas Usage by Customer Segment

Customer Segment	PG&E	SDG&E	SoCalGas
Commercial	8%	22%	8%
Public	1%	16%	3%
Industrial	66%	5%	25%
Agricultural	5%	1%	2%
Residential	20%	57%	52%

[2] https://energycodeace.com/resources (Fact Sheet: Single-family Buildings: What's Changed in 2022.pdf)
[3] PG&E, SDG&E and SoCalGas Energy Efficiency Business Plans, 2017

Gas usage within these segments varies but is generally comprised of water heating, space heating, process heating, and cooking equipment. Table 2 provides Energy Use Intensities within the commercial customer segment as reported in the 2006 Commercial End Use Survey and Table 3 provides Unit Energy Consumption data as reported in the 2019 Residential Appliance Saturation Survey.

Table 2. Commercial Natural Gas Energy Use Intensities (kBtuh-ft^2-year) by End Use

Customer Segment	Water Heating	Space Heating	Process Heating	Cooking
Office	2.30	14.20	0.80	0.10
Restaurant	48.60	7.70	0.30	153.30
Retail	0.80	3.00	0.00	0.50
Food Store	7.70	9.50	0.10	10.30
Warehouse	0.40	2.40	0.40	0.20
School	4.70	10.00	0.10	1.10
College	8.40	19.80	0.00	1.70
Health	31.40	32.70	5.10	3.40
Lodging	29.00	7.30	0.30	4.40
Miscellaneous	9.30	7.00	4.60	1.00

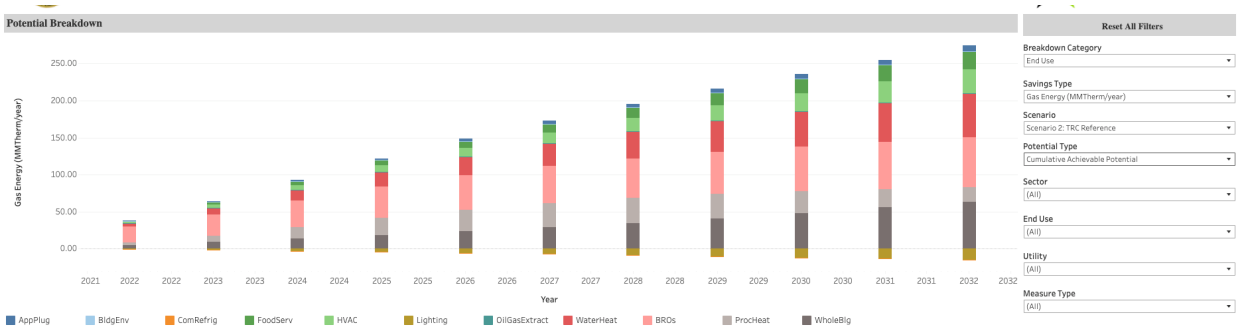
Table 3. Residential Unit Energy Consumption (therms) by End Use

Building Type	Water Heating	Space Heating	Pool/Spa Heating	Dryer	Cooking
Single Family	258	189	200	11	25
Townhome	257	83	179	19	22
2-4 Unit Apt.	246	69	210	18	24
5+ Unit Apt.	248	53	177	17	21
Mobile Home	253	144	220	17	19

The data in Tables 1 through 3 show the greatest gas usage within the industrial and residential customer segment, followed by the commercial segment (except for SDG&E territory where commercial and public sector customers replace industrial). Within these customer segments, process heating, water heating, space heating, and commercial cooking equipment are the predominant users of natural gas.

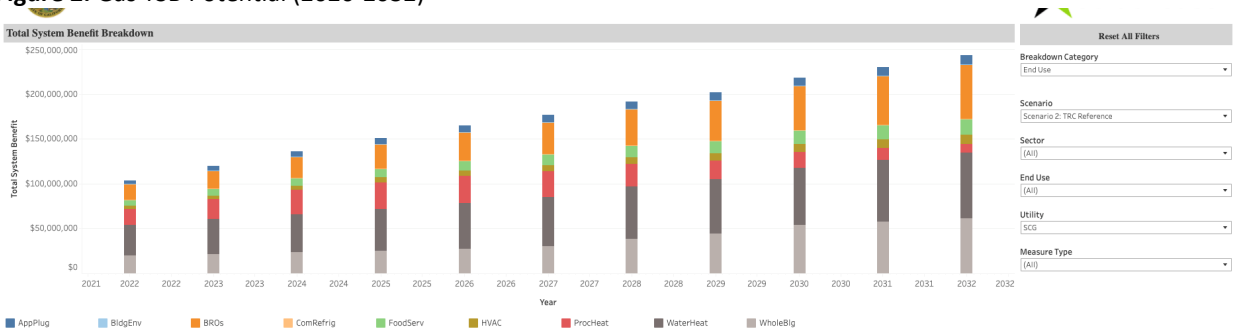
As shown in Figure 1, the Potential & Goals study shows the greatest near-term energy savings potential from whole building retrofits, behavioral/retrocommissioning/operational (BRO) measures, water heating equipment, space heating equipment, process heating improvements and food service equipment. The potential for process heating is diminished over the longer term but largely offset by an increase in potential for space heating and food service equipment.

Figure 1: Gas Energy Efficiency Potential (2020-2032)



In D.21-09-037, the CPUC provided direction that energy efficiency portfolios will be evaluated on a new metric of Total System Benefit (TSB). As shown in Figure 2, energy efficiency potential as measured by TSB provides a similar conclusion as in Figure 1 with whole building retrofits, water heating equipment and BRO measures providing the highest overall level of benefit.

Figure 2: Gas TSB Potential (2020-2032)



The Potential & Goals Study identifies many measures within these end-use categories that have the highest potential for energy savings through 2030 as listed in Table 4.

Table 4: Measures with High Potential for Therm Savings (2020-2030)

Commercial	Industrial	Residential
Condensing Water Heating Boiler	Process Heating	Clothes Dryer
Commercial Cooking Equipment	Boiler Controls	Windows
Gas Furnace	Insulation	Instantaneous Water Heating
Energy Management Systems		Water Heating Controls
Window Film		ZNE Building
ZNE Building		HER

Many of these technologies are further documented as priority items in the Technology Priority Maps (TPMs).[ii]

GET Program Vision

GET's vision is to investigate natural gas energy efficiency technologies that have the added potential to enact a positive impact on global climate change and achieve statewide greenhouse gas emissions reduction targets. GET achieves its vision in a collaborative fashion engaging technology developers and

other relevant stakeholders to align California's gas IOUs needs with manufacturer product development efforts and ultimately deliver energy-saving technologies to the market that deliver customer value.

Purpose of the Research Plan

The Annual Research Plan acts as a research roadmap for the coming year's projects under the GET program. The Annual Research Plan is used to identify strategic research needs that are appropriate for investment by California's gas utility customers. The plan identifies key research needs and solicits information from the GET Technical Advisory Group (TAG) as guidance to ensure the plan has industry involvement. The 2023 Plan has five overarching goals that balance the long-term impacts of the EE Action Plan with the near-term impacts of EE savings potential. Using the plan as a roadmap to guide 2023 activities, individual Project Plans will be developed for discrete projects that support each goal area. The goal for the 2023 Plan is to initiate fourteen (14) emerging technology projects including one technology focused pilot.

Development of the Plan

The 2022 Annual Research Plan[iii] was the inaugural plan for the GET Program. The plan was informed by pre-existing information such as the current gas TPMs, the 2020-2021 Research Project Summaries prepared by Utilization Technology Development, NFP[iv] and input provided by the GET Program team. This information was compared against California legislative and policy direction to identify near-term technology opportunities that aligned with the state's climate change agenda.

The 2023 Annual Research Plan was revised based upon the 2022 research that was completed or is still in progress and additional input from the TAG and GET Program team over the course of 2022.

Managing the Plan

The Annual Research Plan is a living document that is updated each calendar year. Typically, the plan is prepared in Q4 with feedback solicited from the TAG and other stakeholders, and the final draft is issued in January. The current version of the plan (2023 V1.0) will be posted on the GET program website.

2022 Research Outcomes & Findings

In 2022 (to-date), research was undertaken in the following areas

- Water Heating: (3) projects
- HVAC: (1) project
- Commercial Foodservice: (1) project
- Crosscutting/Boiler Add-on Measures: (1) project
- Hydrogen Readiness Labeling of Gas Appliances: (1) project

Final reports will be posted at: Home | Emerging Technologies (ca-etp.com)

Outcomes

Major outcomes from completed research include the following:

1) Water Heating Technology Table (WHTT) with known emerging water heating technologies and their relative priority
2) Initial vetting of high-priority water heating technologies and recommendations for further

study

3) Identification of gaps in modeling tools, codes & standards, and publicly available performance data of high-priority water heating technologies
4) Identification of barriers and drivers for high-efficiency water heating technologies and recommendations to overcome barriers
5) Identification of existing water heating technologies needing further development
6) Identification of barriers and drivers for high efficiency commercial foodservice equipment and recommendations to overcome barriers
7) Identification of commercial foodservice technologies needing further study

Scanning and Screening Technologies

Multiple technologies and approaches were identified and reviewed as part of ongoing studies, input from the TAG, input from other parties, presentation at conferences, and internal research:

- New or lesser-known hot water and heating technologies
- Technologies that improve the energy performance for commercial kitchens
- New or lesser-known industrial and agricultural technologies
- More efficient and lower emission burners
- All technologies listed in the new Cross Cutting section

For further information on these findings, see the final project reports expected in 2023. These will be posted on Projects | Emerging Technologies (ca-etp.com).

2023 Research Goals

The 2023 Annual Research plan includes new and ongoing research into the following technology areas: water heating, HVAC, foodservice, industrial/agriculture process, and cross-cutting equipment.

Water Heating Technologies

Goal 1 and 2 from the 2022 Research Plan were both for water heating technologies. The 2022 research yielded extensive information on the gaps in existing and emerging technologies as well as the readiness of the emerging technologies.

The 2023 goals for this technology area include underutilized existing and emerging water heating technologies. The goals are separated because the objectives and outcomes for underutilized existing technologies (Goal 1) versus emerging technologies (Goal 2, Goal 3) are very different.

Goal 1: Improve adoption of existing water heating technologies in multiple market segments

There are several existing water heating technologies offered in EE programs which have historically seen low participation, and there are some measure offerings that have potential gaps in energy impacts. One specific gap is the lack of therm savings for the measure SWWH022: Smart Pump, Residential. Another gap is the potential additional energy savings or persistence of energy savings when continuous monitoring is used in conjunction with water heating controls.

Objectives

1) Perform field studies of existing water heating EE offerings in the multifamily sector where there is a data gap for being able to claim therm savings for controls measures

Goal 2: Provide data for updated and new measure offerings of emerging water heating technologies

The water heating technologies that have been selected for further investigation are:

- Gas-Fired Absorption Heat Pump Water Heater & Combi
- Gas-Fired Adsorption Heat Pump Water Heater
- Gas-Fired Thermal Compression Heat Pump Water Heater & Combi

2022 research indicated the need for performance curve data for current equipment available in the U.S. market, installation configuration and cost data, maintenance requirement information, contractor training, contractor & customer awareness campaigns, and CO_2 load shapes for these technologies.

The gas-fired absorption heat pump water heater has an existing Measure Package (MP) SWWH033 for only the multifamily (MF) sector. This measure package will require updates based on field study as well as inclusion of other market segments/building types. The goal of this effort is to support the expansion of this existing Measure Package for additional building types and development of new measure packages for combination systems and other system types (adsorption and thermal compression).

Objectives

1) Create steady state and dynamic performance curves for gas-fired heat pump technologies via lab work
2) Generate operational understanding of gas heat pump technologies as required for the measure package update and to better understand system sizing, real time operational issues, and provide an understanding of hourly CO_2 emissions from realistic operating patterns.
3) Gather gas-fired heat pump system design sizing, and installation cost data
4) Gather other information on gas-fired heat pumps to facilitate technology transfer to EE programs such as
    a. Typical applications
    b. Typical installation configurations
    c. Typical maintenance requirements
    d. Required installation and maintenance contractor training
    e. Case studies of successful field studies
5) Create CO_2 hourly load shapes for gas-fired heat pumps relative to electric heat pumps

Goal 3: Provide modeling support and analysis for emerging water heating technologies.

Measure Package (MP) SWWH033 was created to document deemed savings values for the existing gas-fired absorption heat pump water heater uses. When this measure package was developed, several modeling tools were used to estimate savings because no one tool had the capability of modeling gas

heat pumps. Additionally, the eTRM building prototypes that were used were developed in eQuest (DOE2.1) and are now outdated.

It is expected that in 2023 the gas air-cooled heat pump model will be finalized, and the residential building prototypes used in the eTRM will be updated to Energy Plus, which will facilitate improved modeling of these systems. This improved modeling capability will be augmented with data collected through a laboratory and field studies planned for GET.

In addition, there are several expected policy and code changes that will influence market adoption combined with efforts by the North American Gas Heat Pump Collaborative (NAGHPC) to further push these new emerging technologies. An understanding of these combined impacts at scale would help policy makers better understand the impacts of any proposed policy changes.

Objectives

1) Facilitate testing of the GTI developed Energy Plus air cooled gas absorption heat pump model with field and lab data

2) Utilize field and lab test data to calibrate the GTI developed model

3) Use NREL's Restock/Comstock to project scale impacts in CA due to existing, emerging technologies and code gas savings and emissions through 2030.

4) Provide outreach on the availability of modeling tools and potential impacts.

HVAC

In the 2022 Research Plan, HVAC and water heating were combined as one set of goals. For 2023, they are separated because there is at least one technology the GET team plan**s** to investigate that is not common to water heating. Additionally, many of the water heating technologies can be applied for heating and/or supplemental cooling.

Goal 1: Develop better understanding of IR heating in commercial, agricultural & industrial (CIA) applications in California.

GET is currently conducting a study to better understand specific applications of Infrared (IR) heaters in commercial, industrial, and agricultural facilities as there is limited market data regarding the overall levels of adoption in California.

Objectives

1) Finalize current study to understand market penetration and application of linear and area IR EE measures.

2) Based upon output from this study, determine if field testing, measure package development or further market analysis is required.

Goal 2: Explore the application of combi systems in California.

There are multiple systems that have been studied for domestic hot water heating applications only; however, the same technologies can also be leveraged for both space heating and cooling, hence the name "combi" systems. These are mostly proposed for residential applications but could be applied for commercial applications as well.

Objectives

1) As part of field-testing work planned for water heating, quantify applications where the water heating systems serve more loads than just water heating.

2) Explore related applications and requirements for these systems to be applied in multifamily and commercial applications

Commercial Foodservice

Goal 3 from the 2022 Research Plan was related to residential cooking and commercial foodservice. A market characterization study for commercial foodservice (CFS) was launched and is still on-going. Once this project is completed, additional objectives based on its findings may be added. Scanning and screening was done for emerging residential cooking technologies. Technologies for the residential cooking market were unable to be studied by the GET program because they were too nascent or only available outside the U.S. market. There were three CFS technologies that were selected for further study which had historically low participation and one that needs additional data to become an EE program offering. Neither the CFS market characterization project nor scanning and screening for emerging CFS measures yielded any new technologies that the GET program can study at this time. However, the market study did reveal that customer education is a critical but often neglected area to increase EE participation in the CFS market.

Goal 1: Increase the participation of CFS measures in EE programs

The CFS market characterization study showed that a lack of customer awareness is a barrier to energy-efficient equipment adoption which has been found in many previous studies. This study also showed that improved performance, labor savings, and consolidating kitchen operations are drivers for the participation of energy efficient CFS equipment. Therefore, a field demonstration project that educates customers about improved performance, labor savings, and consolidation of operations is planned and will have an outreach component to increase market awareness.

Objectives

1) Field demonstration study(ies) to capture and quantify improved performance, labor savings, and consolidated kitchen operations from energy efficient CFS equipment

2) Outreach event to present the findings of study(ies) to CFS industry partners

3) Data from field studies to support marketing collateral

Industrial and Agriculture Processes

Goal 4 in the 2022 Research Plan was related to industrial technologies. The Industrial and agricultural sectors are fragmented with very specific applications of technologies based on sub-segment and even specific customers within those sub-segments. Therefore, the technology landscape is much different from the commercial and residential sectors which are more homogenous.

Emerging technologies in this segment might have a higher opportunity for savings on an individual project level, but the market size is less than other sectors. Therefore, this goal was the lowest priority in 2022. Scanning and screening work was initiated in 2022 to identify emerging technologies in this sector and is still on-going. Several technologies are being reviewed to determine if they are appropriate for the GET program. Current program offerings for boilers primarily consist of condensing boiler retrofits, pipe insulation and steam traps. While some of these overlap with multifamily and commercial sectors, many of the additional opportunities lie with industrial boilers. A project is currently underway

to identify and focus on underutilized boiler add-on measures, along with potential newer technologies.

Goal 1: Improve product/operational efficiency of natural gas end-use process in the industrial, agriculture, and healthcare segments

This is similar to Goal 4 of the 2022 research plan since work is still ongoing. However, the objectives have been updated since there is more information available now than when the 2022 Annual Research Plan was written.

Objectives

1) Conduct a concerted effort to scan and screen emerging technologies that address process loads in the healthcare segment
2) Identify technologies and controls that can provide "off the shelf" high efficiency solutions to existing applications especially for small industrial and agriculture customers
    a. Underutilized add-on technologies or new style of venturi steam traps may allow for a deemed or hybrid custom solution
3) Review the capability of dedicated IR heaters for drying processes
4) Perform field studies of emerging technologies in the industrial and agricultural sector

Cross-Cutting

Numerous technologies have emerged as having applicability to multiple sectors and/or end use technologies. Thus for 2023, this new category has been created to capture those. The list below summarizes some of the technologies warranting greater focus:

1) Low NOx Burners: Goal 3 of the 2022 Research Plan included objectives that were related to Low-NOx burners. Scanning and screening completed for low-NOx burners in 2022 found that burners are applicable to multiple building sectors and end uses and they should have their own category. These have the potential to both reduce NOx and related emissions, but also slightly increase the efficiency of the device.
2) Catalysts: Similarly, catalysts for existing gas-fired furnaces are being developed which may be applicable to water heating and other end uses as well as well. The GET team's understanding is that the existing measure for CFS conveyer oven already utilizes this technology. These have the potential to both reduce NOx and related emissions, but also slightly increase the efficiency of the device. In applications where condensate is being discharged, these can neutralize the acidic component of the discharge.
3) Carbon Capture: While much of the effort for carbon capture is being looked at for industrial power generation or industrial scaled projects, which is out of scope for GET, there are technologies that focus on carbon capture for demand side uses. In some cases, these take extra energy to remove the captured carbon, while in others, they have an energy efficiency component in addition to carbon capture.
4) Drying: GET has identified a sorbent drying technology that is still in the prototype development phase that may have applications for residential and commercial drying applications.

Goal 1: Reduce the emissions of gas-fired equipment

Low NOx burners and equipment catalysts are used across the water heating, space heating, CFS and industrial sectors to reduce or eliminate emissions. More information is needed to understand what role the GET program can play to further advance these technologies.

Objectives

1) Scope technologies that can reduce the emissions of gas-fired HVAC equipment
2) Determine the technology readiness level of each technology
3) Determine to which end-uses each technology may apply
4) Determine which technologies require further testing and analysis

Goal 2: Quantify Impacts of Catalysts

There is at least one technology that is being developed in this space, but it is not commercially available at this point. GET could facilitate a greater understanding of this technology and its potential.

Objectives

1) Scan and review the full list of applicable technologies in this space
2) Determine technology readiness level of each technology
3) Quantify potential for EE savings
4) Quantify potential for emissions reduction
5) Understand the dynamics of the supply chain for these approaches

Goal 3: Quantify Carbon Capture Technologies

There is at least one technology that is commercially available and is intended to reduce carbon and increase energy efficiency of a boiler system. There is little data on field performance in terms of efficiency gains and carbon reduction. GET could facilitate a greater understanding of this technology.

Objectives

1) Scan and review the full list of applicable technologies in this space
2) Determine technology readiness level of each technology
3) Quantify potential for EE savings
4) Quantify potential for carbon reduction
5) Understand the dynamics of the supply chain for these approaches

Goal 4: Quantify Sorbent Based Drying Technologies

Monitor developments in gas fired sorbent-based dryer technology and intervene as appropriate.

Objectives

1) Monitor the full list of applicable technologies in this space
2) Determine technology readiness level of each technology

References

[i] California Energy Commission, 2019. *California Energy Efficiency Action Plan*.

Energy Efficiency Action Plan

[ii] SoCalGas. *Gas Technology Priority Maps*

[iii] 2022 Annual Research Plan

1)%20Research%20 Plan%20v1.4%20(1).c

[iv] Utilization Technology Development. *Research Project Summaries 2020-2021*.

UTD Research Project Summaries