Appendix B – Natural Gas Research Program's Stakeholder Group Workshop – January 28, 2014

Natural Gas Research Initiatives for 2014/15

Summary of Workshop Participant Questions and Comments with Energy Commission Staff Responses

Buildings End-Use Energy Efficiency:

UC Davis

Commenter: It was commented in one of the early slides that behavior was one of the future directions, but I didn't see that really in the plans for initiatives. I think particularly programmable thermostats and usability have a real impact on heating energy use. I think that behavior is a really important element, and I'm wondering how you see that incorporated into your portfolio.

Response: Behavioral research is included in the water heating and distribution initiative and is also integrated into the natural gas system to achieve zero net energy. So, in the latter I break out that we're looking at things like low cost accurate gas meters, and to analyze occupant's behavior and motivations that could increase energy efficiency of natural gas using systems. So what you've mentioned could fit into that category.

On the water heating and distribution side, we're looking at understanding behavior better to collect information on how people are using hot water so we can design better systems.

LBNL

Commenter: I'll start off with a couple of synergistic things. One is that LBNL is currently doing a study with ARB on ventilation in homes, a link to the indoor environmental quality work.

Also, the DOE Building America Program is running into some of the same issues. Like when we make our homes super energy efficient and air tight, what's the best way to ventilate them and have source control, etc. Brett Singer at LBNL is doing a lot of work on that.

Also, this idea that we want to have really cheap high R value insulation that's easy to install, particularly in retrofits. The DOE Emerging Technologies Program has a big focus on that for the upcoming year. Those are three areas where I thought there were some good synergies between what Brad was talking about, what's happening in the state, and also federally.

On the last point, or question, I have regarding if we're missing some opportunities here, I would have liked to see more effort on what we're going to do in existing homes. Mainly because they're the ones using all the energy, and I know it's a lot harder to deal with existing homes in the state. Brad, I wondered if you had any ideas about how your program could go more in that direction of reducing energy in existing homes?

Response: There is an initiative to improve insulation that would definitely fit into existing homes. Getting back to the water heating side, which would apply to existing homes, we're looking at retrofitting systems to really save a lot of energy in the piping. That's a huge problem with these older homes that have existing piping systems, we can do good things with new homes.

So there's insulation, we're going to go after the existing homes and the water heating and water distribution side. In addition to retrofits,

when systems wear out, there are very efficient new systems and the new standards require there to be adequate ventilation.

Industrial Agriculture and Water:

SoCal Gas

Commenter: Have you considered efforts to green up the pipeline? There is work being done through ARPA-E on solar thermal catalytic reforming of natural gas to produce hydrogen.

Response: Efforts to incorporate renewable natural gas are pursued by our renewables program area. Thank you for the information on the ARPA-E project, we will review it to determine future research opportunities we may want to pursue.

Commenter: Additional work could be done on integrating fuel cells within the grid.

Response: Fuel cells are incorporated in our combined heat and power research. Additional research on fuel cells is pursued in our electric research program.

Renewables:

Commenter: What is the difference between natural gas and renewable natural gas, is it just methane?

Response: Natural gas and renewable natural gas typically have almost the same methane content. One is called renewable natural gas or biomethane when it is produced from a series of upgrading and purification of biogas generated by anaerobic digestion of organic feedstock. Raw biogas contains only about 60% methane with about 40% carbon dioxide and other impurities in small quantities. Cleaning,

upgrading or purification is required to strip the biogas of those impurities and generate a renewable natural gas with about or over 95% methane.

SoCal Gas

Commenter: Consider how to make CHP more affordable in terms of interconnection, permitting, etc. There is a NYSERDA project to reclassify CHP that you may be interested in.

Response: Making CHP more affordable has been among the primary focus of the Advanced Generation program. The program supports R&D that will help reduce the cost of CHP systems including the electricity generation and heat recovery technology, emissions controls that will help comply with permitting requirements, and controls for building integration and interconnection. We recognize however that more can be done beyond R&D, such as addressing the policy requirements at the utility and permitting agencies. A group from the Electricity Supply Analysis Division of CEC, with participation from our program staff, is addressing the policy side of CHP. An example of this is the successful efforts in the CHP feed-in tariff under the AB1613. We will review the referenced NYSERDA project for possible lessons that we can adapt.

GTI

Commenter: Biogas is the renewable part of zero net energy buildings. A framework for ZNE buildings needs to be established.

Response: A framework for ZNE buildings is being addressed by the Building Efficiency program. Along with various efficiency measures, renewable energy generation not only from biogas, but also from solar and possibly wind depending on location, is a critical component for achieving ZNE buildings.

SoCal Gas

Commenter: Gasification is an area worth pursuing, there are many technologies currently on the cusp of being commercial.
Response: Gasification, both the thermal (e.g. gasifier for wood waste) and the biological (e.g. anaerobic digester for wet organic wastes) gasification, has been part of the Renewable Energy and Advanced Generation R&D portfolio for biomass under the Electricity and Natural Gas funding programs. Our aim is to address the barriers for commercialization of gasification technology and help bring it to market.

Natural Gas Pipeline Integrity and Safety:

SoCal Gas

Commenter: I agree with what you're doing. MEMS was an interesting technology, the sensors are interesting. I'd perhaps take it a step further and look at NEMS, nano devices. Not just for the sort of things you were measuring, but also for the gas content. There's something that we're calling a gas chromatograph on a chip. You might have heard of a company called Analytical Pixel, it's a spin out of CalTech, they claim to be able to do the same things you were talking about but on a nano basis for C1, C2, and C3.

Response: That's definitely something that I'm aware of its importance. In particular with idea of putting RNG into the pipelines, we want to know what the content of that RNG is and be able to measure that.

Commenter: When it comes to putting RNG in the pipe, a standard skid is what we really should aim for. Every time we go to take someone's gas, we have to design a complete system from scratch. So if we had a standard system that we would just order and all we

had to do was connect it at the flange, it would be really attractive because right now it is a big cost.

Response: Thank you for that input, I'll definitely keep my eyes open for the chromatograph on a chip development.

Commenter: I'd just like to reiterate my comment on how much more hydrogen, if any, can we put in the pipe. The concept that you're hearing a lot about you either put hydrogen into the pipe, which may or may or may not be a good thing, or you do methanation to convert the hydrogen to methane and then put it in.

Environmental:

GTI

Commenter: I kind of have two questions. I'm a little surprised to see solar water heating in here, it seems to belong in the buildings area, but if it's strictly environmental impact maybe that's what you're going for. Also, it depends on where you're taking your source, and where the alternative energy sources are. Are they in state, out of state, coal fired, etc? I'm just curious how that will work out.

The other question I have is that there's a technology that's partly agricultural and partly environmental, so I'm not sure where it would fit? It's to replace methyl bromide in agricultural applications for disinfestations with something that's natural gas fired so it would be a steam treatment. It has environmental benefits but it fits in the agricultural area, so maybe a combination of those benefits would make it warranted to take a hard look at those things.

Response: Thank you very much. We also had an internal debate about this issue. As you indicated we believe that this project belongs in the environmental area because the proposed study will

focus on environmental issues. Note that our work is interdisciplinary where different groups work together. For example, some of the indoor air quality projects that Brad showed actually are joint projects between the environmental and buildings groups. The solar project will be similar. Brad has a proposed project looking at the technology part of solar water heating while ours is, again, more on the environmental part.

With respect to the second question, it is something that we have not thought about. It is something that the entire division will have to consider in the future.

SoCal Gas

Commenter: With regard to environmental impacts of greenhouse gases, climate change. Methane hydrates along our coast, is there a risk that they will start out gassing as the ocean gets warmer? Is that something that the CEC should investigate?

Response: There is already outgassing going on in the Santa Barbara region. This outgassing actually creates problems because we have to take that into account when we estimate the actual emissions from the natural gas system. But perhaps we are not totally aware of the source you are talking about. Could we get more information from you?

Commenter: Yes, supposedly there are enough methane hydrates along our coast to last us 3000 years.

Response: Thank you very much.

Transportation:

Sempra

Commenter: I like the program the CEC is doing for transportation, it is obvious through our participation in many of the activities. I didn't see anything on home refueling or compression for NGV stations, is it under something else or something that you would consider adding to your program?

Response: As far as equipment for compression, we have a natural gas fueling infrastructure improvements initiative where we are targeting a solicitation release by mid-2014. So, compression would be included for compressed natural gas fueling stations.

As far as home refueling, it is captured in our road mapping efforts. But, it is a lower priority mainly because we are looking at what ARPA-E has funded and we will look for opportunities to build onto that research. As you know, we have been pursuing the opportunities to move to a low pressure tank specifically for light duty vehicles. When we talk about home refueling we are specifically talking about light duty vehicles, passenger cars if you will. One of the items that we are considering is that any improvements that we make to the current system will likely have to be improved if we're successful with our low pressure tank option. So, it's being categorized as a lower priority. But, if there are opportunities specifically building on to ARPA-E's, we will look into those perhaps as early as next year.

Commenter: As you know ARPA-E is coming to an end in this year, 2014, and whatever concepts being developed under that program would have to be evaluated to make a decision on what is the next step. I anticipate that one or two projects funded by ARPA-E that would need additional funding to continue their development and move into commercialization. So, I guess we'll find out in the next six

months where these various concepts have a potential of success and we would like to see them continue their development, and develop a product out of that effort.

Response: Duly noted, also I want to comment that we have an effort to update our roadmap. My expectations are that we have a draft some time in 2014. I expect to see opportunities that would include home refueling and will outline the research opportunities through that road mapping effort. Thank you for mentioning that.

Simple Fill

Commenter: Where do you address the needs of small to mid-sized fleets in your portfolio? So, for instance, think about your electricians, etc. These are all small to mid-sized businesses that could really take advantage of natural gas, but due to the poor infrastructure with compressed natural gas, it's just not effective. There are cars and trucks out there that are available for these small businesses to use. I'm interested in how that fits into your portfolio.

Response: The focus of our program centers on research, and it does include fueling infrastructure for transportation. So, if there are barriers that are preventing the expansion of the fueling infrastructure and research opportunities, including small fleets throughout California, we would certainly be pursuing and/or capturing those and prioritizing across other opportunities.

Now, one of the programs that I also mentioned earlier is the AB 118 program. That program has funded, in the past, natural gas fueling infrastructure. I would think that if we are considering strictly expanding and making it available to a variety of different fleets throughout California, it fits better under the AB 118 program among other activities that are going on such as clean energy that has a strategy for expanding fueling infrastructure. But we will note that, and certainly if there are research opportunities that would address

expanding the fueling infrastructure into small fleets, we will look into that. Again, we would rely on our road mapping efforts to capture those research opportunities.

NREL

Commenter: On slide 86, are you dedicated to on-road testing or would you consider chassis level testing?

Response: For this initiative, our focus is on-road testing in real world conditions. It could be complemented with chassis dyno testing, so I wouldn't necessarily discount it. It isn't the primary focus, but if it can assist in qualifying or validating on-road testing, it could be included.

Commenter: For that on-road testing would you be interested in comparable diesel equipped vehicles to compare against the natural gas ones you test?

Response: That's a very good question, a more general way of capturing that is how can we establish a baseline? I don't think I'm prepared to answer that right now. It could be included, but not to promote conventional fueled vehicles. We don't pursue conventional fuel research. The limits to performing comparable testing will be specified in the solicitation.

Westport Innovations:

Mid-Size Engine Integration and Demonstration

1. Inclusion of Class 8 Engines

It would be greatly beneficial to also include Class 8 vehicles as well where some mid-size engines can be used. Class 8 vehicles are the biggest user of the fuel and where most of the emissions are

generated. Many of the technology improvements that are either targeted for medium or heavy duty engines are applicable to both.

Response: This initiative builds on previous engine development efforts suited for Class 3 through Class 7 (PON-12-504). The smaller engine sizes (6 to 8L) are not suited for Class 8 vehicles, and therefore we are targeting Class 3 through 7.

2. Comprehensive Projects that include multiple phases

Engine development and engine integration into demonstration vehicles are two distinct activities. Since the overall intent is to facilitate commercialization of new technology, it should be noted that if the expectation is to include both new technology development as well as its demonstration in the field then the timeline and budget for such projects should be adequate to allow inclusion of both activities into a single project.

Response: The intent of this initiative is to fund single projects that include integration and vehicle demonstration. Keep in mind, there may be a need to do final engine development as well.

3. Examination of other technology barriers to NG market penetration

Are ‘limited engine options’ really the main barrier to NG penetration into certain segments? Could examining the market needs of NG engines provide a better focus on addressing the key issues that prevent uptake of NG engines in these markets?

Response: The Natural Gas Vehicle Research Roadmap (CEC-500-2008-044-F) captures Vehicle Integration as a key action to greater NGV availability and market penetration. Future roadmap efforts may provide a different perspective to NG market needs, and we would in turn attempt to address those needs through future research initiatives.

4. Realistic benefits from on road use testing

Stationary engines and CHP systems have very different duty cycles and hence are likely to have different challenges and opportunities from those of an on-road engine. The assessment of concepts for on-road use should not focus on aspirational benefits that are unlikely to be realized in practice in other applications. Different goals for expected results should match the testing type.

Response: The focus of the research is to integrate and demonstrate mid-sized natural gas engines into vehicles, two key tasks necessary to commercialize the natural gas engine. The benefits to stationary engine application are to have a commercially available advanced natural gas engine that may otherwise not be available as a potential engine option. Yes, further development would be needed to operate in a stationary engine application.

On-Road and Advanced Emission Testing for Fleets

1. Challenges to in- fleet testing

There may be difficulty obtaining representative vehicles / engines especially in such a rapidly-developing field. Focus on fleet operations may result in findings that are based on older engines with poor efficiency and high GHG emissions than new available products. It should be possible to include so that the newest engines are being tested in these studies.

Response: The prioritization for engine technology and vehicle application will be included in the solicitation. The newer engine technologies are the primary focus for this initiative.

2. Development of realistic in-use engine and dynamometer cycles

It is generally acknowledged that engine certification results do not provide a good representation of actual in-service conditions. Fleet operations testing is also likely to be selective, and very fleet- and vehicle-dependent. Developing a set of standardized, engine and chassis dynamometer cycles that are representative of aggregate fleet operation in different market segments would provide a more balanced assessment of engine emissions and fuel consumption throughout California.

Response: There may be an opportunity to update and standardize engine and chassis dynamometer test methods suing the results of this research.

3. Evaluation of the true GHG and emissions benefits of NGVs

On the topic raised in (2), what differentiates NG vehicle duty cycles from diesel/gasoline vehicle duty cycles? What emissions benefits are from engine and what from vehicle mass/drag reduction? Equivalent testing of natural gas and diesel vehicles operating in the same duty cycle/application /route. It may be challenging to accomplish with in-use testing without an established framework.

Response: Duty cycles for CNG target markets compared to conventional fueled vehicles would be the same. CNG vehicles might have some additional mass due to storage and potentially longer wheelbase to accommodate storage tanks. The “framework” in terms of a test procedure would need to be consistent for both the baseline and NG vehicle testing in order to validate the results.

Current portfolio highlights: upcoming initiatives

1. NG hybridization

The idea of hybridization of NG vehicles has not been shown to be attractive from a market point of view. Incremental weights and cost, payback and net benefits are market concerns.

Response: While there are concerns from a market standpoint for conventional hybridization, the objective of this solicitation is conduct research that develops an optimized solution for a given application that minimizes cost while maximizing benefits in fuel use, emissions, and efficiency. While hybridization may not be ideal for all applications, this research is intended to target the applications best suited for electric hybridization.

2. Natural gas fuelling infrastructure improvements:

a. LNG station storage venting and mitigation strategies, such as flaring/catalytic oxidation.

b. CNG fugitive emissions related to crankcase and tailpipe Improving density of CNG storage and reducing system cost

Response: This research initiative does not include LNG fueling stations, however, LCNG stations are included focusing on the compressed natural gas fueling. This research initiative does not include mitigating fugitive emissions on the vehicle side.

3. Engine efficiency

Specifically, the integration of efficiency improving technologies, such as turbo compounding and efficiencies of spark ignited (SI) engines.

Response: Advanced natural gas engine technology development will continue in the future driven and guided through the development of a new Natural Gas Vehicle Research Roadmap.

4. Engine Combustion

Focus on novel combustion approaches including advanced ignition strategies, engine cylinder actuation (e.g. variable valve actuation) and air handling (e.g. advanced turbocharging).

Response: Advanced Ignition for natural gas engines is a planned solicitation expected to release in mid to late 2014.

5. Fuel Quality and Composition of Natural Gas

Composition and quality of natural gas varies widely and it is highly desirable that diagnostic and corrective sensing and controls technologies are funded to build a more robust natural gas engine that is tolerant of fuel quality variations.

Response: Fuel Quality and Composition of Natural Gas is currently being explored in an on-going project with UC Riverside. As project completes, additional opportunities will be captured in the published final report.

6. Robust after-treatment treatment

Currently there is no robust exhaust after treatment technology available to treat unburned methane. Even though exhaust methane emissions are not currently regulated in the US, it is important to fund technology development to bring a more effective and robust methane oxidation catalyst for lean burn natural gas engines into the market.

Response: Advanced after-treatment technologies will be explored and research opportunities will potentially be identified and prioritized in the revised Natural Gas Vehicle Research Roadmap.

7. Particulate Matter

Particulate matter, particularly very small PM, will likely become subject to greater regulation. While NG engines are generally considered to generate very low levels of PM by mass, number counts do need to be considered, especially using base engine designs based off of diesel platforms.

Response: PM emissions are being measured on new engine development projects, including quantifying beyond regulated levels.