MODERATOR: Good morning. Let's get started. I'm Steve Chalk, the DOE Hydrogen Program manager, and welcome to the Department of Energy's 2006 Hydrogen Program Review.

Got a very busy and exciting week ahead of us, both peer review, over 250 projects funded by, at least partly by the taxpayers.

And this feedback that we get from the peer reviewers, and we really thank the peer reviewers, will be used by the DOE managers to influence our FY 2007 budget decisions project by project. So this is a very important meeting in examining the progress and our portfolio as a whole.

We're in the third year of the President's Hydrogen Fuel Initiative, and really in all-out execution mode now.

Our planning is done with the exception of continuous refining and so forth. Obviously as any good planning is done, we've selected over $500 million of competitively awarded projects. That's almost $800 million, if you include private cost share.

So we've set this meeting up today, the plenary session, I should say, really to focus on results. A lot of meetings in the past, of course, developing the national road map, identifying the barriers and so forth; but today we're really focused on results.

And you'll hear projects from the Office of Energy Efficiency, Fossil Energy, Nuclear Energy and the Office of Science.

We hope next year to include Department of Transportation, their projects, and the portfolio and then also the projects that are being done under Interagency Traffic Force as required by, required by EPACT.

And we thank Kevin Hearst and the White House Office of Technology and Policy for leading that group. There have been a couple of important things taking place over the last year and really first is the President signing into law the nation's first comprehensive energy legislation in about a dozen years.

And there's lots of opportunity for hydrogen and fuel cells, for example, Title VIII that Congress passed matches up perfectly with the time lines and the approaches and the department's plan and support of the President's Hydrogen Initiative. Title VII outlines potential near term opportunities, where the government and states can play an early adopter role for small stationary fuel cells and portable fuel cells and things like that that are very close to meeting the market requirements in terms of technology meeting the market requirements today.

So EPACT has really codified more or less the President's Hydrogen Fuel Initiative.

Now, in recognizing that the initiative's been underway for two and a half years, again we want to focus on results this morning. First up will be Sunita Satyapal, and she'll go through the hydrogen storage results. This, as you know, is one of the critical barriers to the hydrogen economy. Valri Lightner will follow up talking about fuel cell cost and durability challenges.

Then we'll have an interactive panel session where we want to hear questions and comments from the audience and people on the webcast, and Tim Fitzsimmons from the Office of Science will join that panel session. As you know, the Office of Science last year during the review announced about $70 million of basic science projects in support of the hydrogen economy. So those projects have just been basically negotiated and they're underway, but Thursday we have a special session where we have the principal investigators for the basic storage projects and the applied storage projects getting together to talk about what's required for the hydrogen economy.

Let me just make an announcement, if everybody could turn off their cell phones, that would be appreciated.
(Laughter)
Okay. So recognizing that we've been underway -- just turn that off. Thanks. The second session is for the hydrogen production. And as you know one of the major advantages of hydrogen is the feedstock diversity where we're dependent on one source for petroleum. We have presentations from Lowell Miller from Fossil Energy this morning talking about the coal-based hydrogen and we have Carl Sink, nuclear-based hydrogen and Pat (inaudible) natural gas production and technology the progress there. And then also talk about the host of renewable options that we're developing for the hydrogen economy.

And again Tim will join that session along with Mark Paster, who will talk about the delivery technologies, and that's very critical from a cost and energy standpoint, removing that hydrogen that's produced centrally from the plant gate to the point of use.

So we have those and that will be an interactive session. Tim will join that from the Office of Science as well. Then we have some follow-up presentations, very important areas, Department of Capture and Sequestration and FutureGen, Sean Plasynski inaudible) and Joe Giove from the Office of Fossil Energy will talk about those. And then I would like to say we're working in pretty good harmony with the international community. We have the international partnerships with the hydrogen economy, 17 companies or countries involved.

And in the spirit of that we have Dr. William Borthwick here from the European Commission, and he'll talk about the progress and the coordinated effort in Europe towards hydrogen.

So as I mentioned, we had a couple major events. I mentioned one, EPACT, which is important to the hydrogen initiative. The other one is President Bush's Advanced Energy Initiative. And in that 2006 State of the Union he strengthened his support for hydrogen. I think, more importantly, we've established more aggressive near term portfolio for breaking our dependence on imported oil. And the advanced energy initiative is really where our special guest comes in today, and that's Assistant Secretary Andy Karsner who is here. And we're going to ask him to give us his perspective on the Advanced Energy Initiative, among other things, which I'm sure he'll do.

But first I want to introduce my boss, who will introduce Andy. That's Richard Morer. And he's the person in charge in energy efficiency and renewable energy of all the technology development programs. Welcome Deputy Assistant Secretary Richard Morer.
(Applause)

>> Richard: Good morning, everybody. I have a very short and simple role this morning. That is to introduce our new assistant secretary. I'd first like to welcome everybody to this event. It's great to see so many folks here, and see so many faces I actually recognize.

When I was standing at this podium last year, as I recall, I was talking to all of you about our, at that time, relatively new Secretary of Energy and the tough and challenging questions which we were referring to as the Baudnum question which had us all pulling our hair out and doing some serious soul searching about the work we were up to. And just when I thought every tough question on earth had been placed in front of us, along comes our new Assistant Secretary Andy Karsner; and Andy has a couple of difficult questions to pose to us to challenge us and I think we get better and better with it with each exposure.

We that, it's my honor to introduce our new Assistant Secretary. Andy Karsner comes to us with some unique experiences of his own from the private sector. He's been involved in project financing in the world of renewable energy, and I believe brings a relevant set of skills to our office that for many of us are quite foreign and new, but I think are extremely critical to moving us to the next stage with all the renewable technologies and efficiency technologies that we're working on. And so with that I'd like to introduce Andy Karsner.

(Applause)

>> Andy Karsner: Good morning. Thanks, Richard. Very nice introduction. I didn't know my questions were that tough. But I was just throwing softballs in the early days.

Good morning. Thank you all for being here. I'm not going to speak long today. You all have very, very important work to do. And my voice, frankly, pales compared to the enthusiasm of our Commander in Chief for the future of the hydrogen economy. He's spoken to it at length over the years since he began the initiative most recently on Earth Day. But not much can be added to the forcefulness of his commitment or leadership that's demonstrated by the United States, the president to support what he sees as the hydrogen economy.

Let me begin then with the obvious place, the President's pragmatism and the sense of urgency you heard in the state of the union, and what I would characterize as moral clarity. America is addicted to oil.

Accepting the premise that addictions are unhealthy and counterproductive, and a danger to our national vitality, the first step is to address an unaccessible overreliance on petroleum that threatens the country's prosperity, security and natural resources.

I don't have to remind you that we're a nation at war, and America's energy dependence on foreign sources of oil is a growing source of national security concern.

We inhabit a world that is warmy and the repercussions on dependence on fossil fuels is no less a source of trepidation. In addition to the problems of the present petroleum transportation economy that hydrogen seeks to tackle, 70% of all electrical power in these United States is obtained from fossil fuels using traditional combustion which generates air pollution and greenhouse conditions and impacts human health and our environment.

You all understand the problem very well. That's why you're here in this room. And though you may have varying perceptions on the degree of its impact or the depth of our oil addiction, it is clear that we have an obligation to aggressively seek to get beyond it.

Because of the efforts of you all, the people in this room and the people who support our programs, we can confidentially pursue a very positive angle on the evolving national energy story as the leaders who will ultimately induce the hydrogen economy to which we all aspire you committed to making this attractive technology a main stay of the nation's and indeed all developed nation's economic and environmental well-being.

If we project into the future to the finish line for this race to achieve a full national and potentially global commercialization of the hydrogen economy, it will not likely be characterized by single mindedness and linear progress at a constant and regulated pace, but rather by multi-faceted angles of approach, adaptation, agility and perseverance, interacting with an evolving landscape of economic opportunity. Full commercialization of the hydrogen economy is our national energy destination.

Assuring that we accurately and intelligently manage its course, then, is in fact our duty. It is important therefore to credibly measure both our progress and our prospects not only now as we embark upon the fourth year of the president's historic commitment but for years and perhaps decades to come with sufficient frequency to learn from the technologies intrinsic requirements institutional and logistical challenges and its market-based applications. We must not see the course to victory and the ultimate emergence into the hydrogen economy as a short-term sprint that will be concluded with a singular event or decision or closed series of seminal events that delineate a petroleum past from a virtuous hydrogen future.

We should anticipate the potential, rather, for a protracted period of development overlap and interaction and co-existence with emerging alternative sources and energy prime movers and welcome the diversification of post petroleum possibilities.

In all probability, most of us who believe in the ultimate beneficence of a hydrogen economy understand that we must be committed to the marathon of market transformation that in fact lies ahead.

We do not control and we cannot foresee all of the factors that eminently impact the length of the journey to this hydrogen economy, and we do a disservice to our cause if we delude ourselves or others into believing that macroeconomics, global energy price volatility and near term petroleum displacement alternatives have no bearing on our timing.

We can and we must soberly account for all the factors that will help us understand and manage the road to the hydrogen economy better. But we must also assure ourselves that none of these factors will dissuade us from our course or our destination.

To this end, as Steve mentioned, we shall continue to enhance our cooperation with the Department of Transportation and our collaborations, beneficially, with the Office of Science. The office of nuclear energy, the Office of Fossil Energy and the across the federal government. We do these things together with the exponential expansion of ethanols and bio fuels that the president spoke of and the advanced energy initiative.

Their growth that's currently underway is a positive development in addressing our near term addiction to oil. The Department of Energy will continue to aggressively encourage and support these trends to maximize home-grown sustainable resources.

In my judgment, the burgeoning domestic fuels industry, domestic bio fuels industry, rather, is not a competitor to the hydrogen economy that we envision but is rather an improved pathway, both heralding and paving its arrival. By comparison to the planning and execution of commercialization for the hydrogen economy that we see, and you will be discussing in these days, very minor manufacturing technology and infrastructure modifications to the petroleum economy are necessary for bio fuels to gain significant market share.

And so we are presented with the fortunate opportunity to measure in real time the rate of early policy pressure and economic process, progress as an analog to the hydrogen economy.

We also benefit from the understanding of the economic realities underlying resistance to alter historically embedded patterns of vehicle production and fuels distribution. These lessons can only serve us to be more agile and pragmatic and poignant in our projection.

And accordingly to plan the hydrogen economy future better.

The hydrogen community, you all, many of whom also participate in the bio fuels arena, should follow the progress of near term petroleum alternatives with an eye towards incorporating lessons learned on efficacy and efficiency of market penetration processes and the market obstacles that we are encountering along the way.

By doing so, even when technology readiness may be imminently at hand for hydrogen, we will have a more seamless understanding and preparation for the forces shaping the potential and rate of commercialization.

Not only will bio fuels potentially become a valuable regulatory policy and economic surplus to clear the past and ease the way, the hydrogen's ultimate arrival. It should also increasingly be regarded as an excellent carrier fuel for transition to the hydrogen economy, as commercial and technical milestones are reached and the fuels marketplace continues to evolve.

I don't need to elaborate this morning in great detail on the substantial technology and infrastructure pitfalls and obstacles and challenges that remain to be resolved before scale economics can be considered for the transportation sector. You all are aware of these things and that is why you have gathered. These problems, as the department has been pursuing and your attendance here is testament to your willingness to contribute to the solutions.

I know from the extraordinary dedication of Steve Chalk who has ably managed our program and JoAnn (inaudible) and many of the distinguished and devoted hardworking members of the hydrogen team in our office, that Thomas Edison's maxim about the necessary mix of both inspiration and perspiration is as true today as ever.

In fact, I'd like to recognize the employees of the Office of Energy Efficiency and Renewable Energy that are here amongst you. Could you all stand up. Come on, there's more of you than that.
(Applause)
I think it says everything that you all would be moved to applause without even being asked to do so. I'm very privileged to serve along side these fine people as they serve our nation and they serve your community and they serve this cause with distinction.

It is your time here in Washington progresses, I want to encourage you to get to know them. Sounds like you already know most of them not just for their scientific and technical and managerial talents but for their fine character and their patriotism and slavish devotion to doing the right thing and to serve this nation and to better our world.

And many of you too are here because you grind away on a daily basis on things that sometimes seem to be intractable obstacles that lie in the path in our road ahead. Perhaps the focus of the difficulties may be hydrogen storage and delivery. Others of you may be concentrating on production, with an aspiration to assure that we come to produce hydrogen free of emissions or new sources of carbon dependency.

Whichever facet you are devoting your talents and labors and attention, it is certain that the product of your research and development and deployment will eminently produce the crowning jewel of America's energy future. A rich source of abundant, domestic energy without emissions that transforms the way we power our homes, offices, cars and trucks and fundamentally changes the global energy economy.

While the Department of Energy remains grateful for its partnerships, many of you in this room some of the largest multi-national corporations whom we have together pursued this endeavor, we especially want to reach out with increasing frequency and recognize with a renewed sense of appreciation the smaller and medium sized risk takers that form the entrepreneurial engine of creativity that is propelling the hydrogen economy into the future in ways that the best designs of government could not yet begin to imagine.

The companies that are producing stationary fuel cells today, for example, privately developing their technology, creating jobs, posturing themselves in the market and pacing themselves appropriately for the duration are heroic in my judgment and I'm requesting a full review of our program might better connect with these champions of the economy and utilize available policy tools to further catalyze their market driven growth. In this respect we welcome your contributions and ideas and ingenuity.

As we begin ascending to a new planning plateau for the market applications of hydrogens, and we can view the horizon with ever clear perspective. We've not yet begun, for example, to cultivate the possibilities of utilizing Title 17 of the Energy Policy Act, the loan guarantee, where they might enable and accelerate commercial transactions and innovative uses of hydrogen fuel cells. But we will in search of the support of free enterprise that ultimately will determine the rate of the hydrogen economy's arrival. And I encourage you to use these meetings this week and to meet continually to help us consider and evaluate such new ideas.

In the bigger picture, you know that many outside of this room have become resigned to the idea that in the name of global economic interdependence we have no choice in this matter of oil addiction. Indeed, they might argue that our children are destined to have their economic face tied to the reliability of unstable regimes and extreme autocratic, sometimes theocratic, ideologies. I'm not a believer that this great nation's fate must be bound to the present paradigm of petroleum's diminishing returns, and I'm grateful that America's great energy pioneers were never stuck in the present tense either, however compelling the status quo may sometimes seem.

Ben Franklin, Thomas Edison and Einstein and Oppenheimer never accepted status quo which in fact served them well in their life times. They never accepted that this was the only course to the future. And thankfully neither do you, the pioneers of new energy in this room.

That is why I believe knowing as many of you as I do, that more than all the government plans and federal contracting to provide your creativity and agility will matter most.

The President and Secretary Baudman are challenging you and me and the entire nation in the great tradition of bringing America together around a common cause to exercise your professional experience for this national purpose and to dedicate yourself to continuous support of economic viability of a hydrogen economy that will displace our dependencies and addictions with a new era of economic growth and international security and environmental health and personal freedom. Our obligation to you is to be committed and to be candid and credible public servants, to work with you openly in the face of the practical realities and the great technological and economic challenges that in fact confront us.

We seek to be catalytic, iterative and above all relevant to your efforts and to bring the best to the public private efforts and cooperation to the fore. We will not in the next 32 weeks, or 32 months remaining in this administration, be unable to unwind fully more than 35 years of growing dependency and oil addiction. But we will work with urgency as never before on the road to which many of you have already begun and we will exert federal leadership in this collaboration with you, with renewed strength so that my children and yours might say that at the dawn of a third American century, in the wake of the greatest attacks that our homeland has ever suffered, that people of all professions, people of all parties, people of goodwill came together in a determined way inspired to dream that which never was and then work relentlessly to bring it into being.

On behalf of Secretary Baudman and a President who strongly advocates for your dreams, and a nation that awaits your results, I want to thank you for who you are and what you do and what you will do to secure our future and to better our world. Good luck in your meetings and thank you.
(Applause)

MODERATOR: Thank you very much, Andy, for that very inspiring challenge to us and the community here this week.

Now we're going to start the first session on hydrogen storage and fuel cells, and we ask Tim Fitzsimmons to come up as well. I know Tim is here. Thank you, Tim.

We have a very busy agenda, I just wanted to mention also that we're going to have working lunches. In fact, during lunch today we will hear from Kristy Cooper, our education manager, and she will talk about a hydrogen education survey that we've done and what we've coined as H2IQ so you can find out how much people know in various target audiences about hydrogen based on surveys that we did in fiscal year '04. Then tomorrow we'll have Grant Fu, the IP Secretariate update us on what's happening around the world and with the IP organization. And then finally Thursday Keith Whipsky from the National Renewable Lab will give us results on the vehicle and infrastructure learning demonstration. We have a fully packed week.

And now I want to turn it over to JoAnn Miliken who will be your MC for the rest of the plenary session. Thank you.
(Applause)

MODERATOR: Thanks, Steve. Good morning. Great to see so many people here. I just got back from vacation so my mind is clear and I can absorb all the information I'm going to hear over the next week.

As Steve mentioned during the remainder of the morning we're going to hear about activities in progress under the hydrogen fuel initiative, as well as under some related programs here and in Europe.

The next hour is going to be devoted to hydrogen storage and fuel cells. We'll begin with a couple of brief talks by Sunita Satyapal, our hydrogen storage team leader and Valri Lightner, our full cell team leader. And then we will open the floor to questions from both the audience here and from our webcast.

So Sunita.

Sunita Satyapal: Thank you, and I'm pleased to talk about hydrogen and storage activities in the last year, and as Steve said it's one of the most challenging that we faced. And so in the next 20 minutes I'd like to talk to you about what exactly the challenge is and what DOE's strategy is to address that challenge. And then focus on results, how we've been spending taxpayer dollars in the last one year, and I would start -- like to start off by acknowledging all of the hydrogen storage teams and especially all of the researchers who really just started, most of whom just started in the last year.

And then finally future plans.

The challenge is basically how do we store hydrogen on board a vehicle to meet all of our performance requirements, competitive with today's gasoline internal combustion engine vehicles. We have acceleration and so forth. Of course, safety and cost. And in the North American market, consumers demand at least a 300 mile driving range. So the challenge is how can we do all of this without compromising passenger or cargo space and meet that challenge we've defined specific requirements in partnerships with industry, and we have many targets that can be seen on this website and here I show you basically the top three. Wait, volume and cost in any unit of your choice. But to go, to show you an example, in 2010, our fixed weight percent target means that if you have a system, for example, that's 100 kilograms, reasonable example, then 6% by weight is the hydrogen storage target.

So in other words six kilograms out of the 100 is going to be the hydrogen. And you might think that's not very much hydrogen, but that's actually very challenging to achieve and in fact the 2015 target is supposed to be for all of the light duty vehicle platforms, and you would need about five to 13 kilograms approximately to meet our challenge.

Those are extremely challenging but I would also like to emphasize these are system targets, and we hear from researchers who are developing materials like metal hydrides and so forth, and I know for the hydrogen storage community, a key thing that's over and over again, and in fact I told many of you recently that instead of signing my name Sunita Satyapal, I was about to sign storage systems, because we still see people reporting material capacities saying that we have metal hydride that needs 6 weight percent and we've met the DOE target. But the system includes not just the material but the tank and all the peripheral installations and so forth if you need it. So a reminder to the community the material capacities must be higher than the system target to meet the system target.

But we are beginning to see people report weight percents in the literature, and I'd like to remind the community again that energy density is really critical or volumetric capacity. And this shows you where we are today. Gasoline system again very high energy content per liter and where our 2015 target is.

And you can see people say this is a very aggressive target but it could be even more aggressive if we didn't have the fuel cell efficiency improvement. But the main message of this slide is if you look at high pressure hydrogen or liquid hydrogen by itself not even with the system, it falls short of the system target.

And so what our program is looking at really is material-based technologies for the long-term, and this chart on the right shows you some examples of materials to meet our target we want to be in the top right quadrant. And you can see that there are many materials that have higher than liquid hydrogen energy density, even more than twice as much liquid hydrogen energy density up in this quadrant. The strategy is to select materials with higher material capacities than the system targets.

We've talked about material capacities, but to give you an idea of where we are in terms of current status of systems, we monitor progress and again you can see none of these systems meet the targets, which are up in this right quadrant. And we're also starting to get a handle on costs for various technologies. But even assuming high volume manufacturing, we don't meet our target.

And so the strategy was to launch a grand challenge in hydrogen storage two years ago, and we established a national hydrogen storage project. For the first time a very focused concerted effort with three centers of excellence, as well as our traditional independent project. And basic science is critical to all of this and will interact strongly with the applied program. And really compared to fuel cells, for instance, which has received significant funding from both industry and federal funding over the last decade, storage has always been relatively scattered low level effort over the years. We were really focusing in the early days on on board fuel processing. So storage has really started the effort in the last couple of years.

And you can see all the number of universities, companies, federal labs involved. We agree with the national academy's recommendations that DOE should continue to look at new concepts and ideas, because success in overcoming the major stumbling block of on board storage is critical for transportation fuel cells.

And as part of our strategy, the focus again is on materials-based technologies. Our goal is a systematic approach, both theoretical and experimental, and really the idea is to tailor properties capacity, kinetics and so forth, and all the movie clips I'm showing are courtesy of Boris (inaudible) from Rice University, part of the Carbon Center, and just an example of how the idea is to start from the ground up and actually tailor materials for the right finding energy, the right capacity and other parameters.

And as part of the strategy, we have a broad portfolio, and we recognize early on that different options have different pros and cons. And here we show other targets besides weight volume cost, and really a snapshot of green represents where we think we can meet the target. Red is where there's a significant challenge, and actually all of these many of these are actually red. The orange are different shades of red, and yellow. But basically with chemical hydrides, for example, hydrogen is bound very tightly. So we may meet some targets but you'd have to regenerate off board. With metal hydrides, hydrogen is not bound as tightly. And you may have good volume but you have other issues, temperature, pressure refueling, and then with absorbants such as carbon, hydrogen is weakly bound. So you may need to cool it to get sufficient hydrogen capacity.

So really the main point is that we have a detailed R&D plan. We have tasks in all of these areas, milestones. Go/no go points and the strategy is to make sure we cast a wide net at this early stage and don't go into the program with blinders on and preselecting a certain technology.

And consistent with the strategy shown here, our budget. Since the start of the press the hydrogen fuel initiative we've ramped up storage and the idea is to have critical mass in hydrogen storage and across the various technology options.

And I'd also like to emphasize the increase, the planned increase in the Office of Science budget for basic energy sciences, and this is for all of the basic science for hydrogen. But, for example, in fiscal year '06 about seven million of that is for hydrogen storage.

So we definitely see an increasing role and more synergy with the Office of Science. . Now I'd like to switch gears and talk about some examples of progress in these three main areas of metal hydride chemical and absorbants. And there's actually a lot more than this. There's a lot of information here and you'll hear about progress throughout the weeks. But this really gives you a snapshot of some examples. And if you look, scan through the main point is to see that there are many new materials that are starting to show high capacity, both in terms weight percent and volumetric capacity, if you can see in the red.

And really a lot of these are new materials, and if you look a little more carefully, though, the temperature, for instance, are not optimum. So we're very excited about these results but there are still many issues and this gives you, you know, snapshot of the forest, or a part of the forest. Now what I'd like to do is go in and show you some examples of a few trees in each of these areas.

So, first of all, we think that rapid screening, both theoretical and experimental is really critical, and that would let us rationally and very systematically, but quickly, assess where there may be promising materials. Show an example DE is using IR imaging to very quickly look at areas of high hydrogen storage capacity. And another example, UOT, is looking at some of these systems shown in the right, and, for instance, they've looked at over a thousand material mixtures, and so far, for the conditions they've used, which would be optimum, it doesn't look like the alanate mixtures they've looked at so far would meet the targets. But this is really critical, because this helps us to more widely expend our resources before we go off in certain directions.

So this whole area of rapid screening and theory is extremely critical. Now with metal hydrides, another example is destabilized hydrides that we find very exciting. This is work by John (inaudible) and Greg (inaudible) and coworkers at HRL, part of the metal hydride center. And here the idea is instead of starting from this ground state and cycling to the conventional dehydrogenated state up here you create an alloy intermediate state and you can cycle between that and basically reduce your energy requirements and your temperature. And what they've found is several of examples where they've been able to reduce the temperature. You still reduce capacity slightly, but for instance, they're starting to show even nine to ten weight percent in some systems and reversibility, you can in some cases reduce the temperature requirements significantly. However, kinetics is still slow when you lower the temperature. So the next step is to look at nano engineering, basically reducing the diffusion distance in some of the next generation promising systems.

Now, with chemical storage, I'd like to highlight two examples. Air products has looked at organic liquids, and it's shown over seven weight percent and very high volumetric capacity to put this in perspective our 2010 target is 45 grams of hydrogen per liter system so at least their material is above that. And they're starting to look at catalysts at an early stage, making sure they're reducing the platinum content at an early stage. We think this whole area, especially if you can get a liquid hydrogen storage carrier, very, very exciting.

And another area is ammonia borine, which is new. By Tom Autry and coworkers at TNL, part of the chemical hydrogen center of excellence. And they also have a new project in basic science. And here the idea is to coat this material in a nano structured scaffold. What was very exciting is they were able to reduce the temperature required to release hydrogen to less than 80 degrees, and get reasonable high capacity. And also reduce unwanted byproducts. So this whole concept of nano structures and combining materials in these types of scaffolds is one that we find interesting. Kinetics is still an issue and here's an example of a catalyst actually looked at years ago by Craig Jensen which is now resurfacing, and we have researchers working on improving kinetics significantly in many of these systems.

With carbon or absorbants, I'd like to highlight two areas: Metal organic framework. Discovered by Omar (inaudible) and you can see the examples, metals, combined with linkers. He showed over seven weight percent of hydrogen storage. However, you need low temperature. Liquid nitrogen is required for this capacity. He's shown several cycles of reversibility. But really the next steps, one area we find very interesting is the concept of spill-over. This is work by Ralph Yang part of the carbon center of excellence. And here the idea is to have combined metals with an absorbant, carbon or another support and that would basically help to attract the hydrogen so it spills over to the support and enhances your hydrogen storage capacity.

So they've actually found four fold enhancement in hydrogen storage via spill-over. So the whole concept of combining a metal with a unique substrate is one that we're actively looking at, and theoretical results are extremely important in the early stage. Again, this is data from Boris (inaudible) and these are just not pictures or movies, they're really calculations to look at what kind of structures are most stable, how can you optimize the distances so you get sufficient binding of hydrogen and sufficient density of sight. And once you get that optimum structure, how do you make it, for instance (inaudible) will talk about the carbon nano tube carpets they've been able to grow. (Inaudible) will talk about some examples of metal and absorbant systems, net cars, for instance. Basically, theoretically, looking at how can you have high hydrogen capacity and then trying to model and simulate what are the best properties to get the right temperatures, pressures and so forth.

I'd also like to highlight testing and analysis, which is critical. We have an independent test facility that we've established at Southwest Research Institute. It's not trivial to measure hydrogen storage capacity in many of these materials. So the idea is to have an independent facility that as promising materials are developed, these can be validated and we're already starting to send samples there and you'll hear about that as well this week.

Another important area to highlight is the storage systems analysis working group. We have worked, for instance, at kayaks and Argon really looking at the overall system in parallel to the materials research.

For instance, as we start down selecting materials we need to look at the overall efficiency for the various approaches in terms of primary energy consumption. We're coordinating with H 2 A and Mark Paster will talk about that during the delivery section. But really the idea is to make sure that we're not using, you know, let's say five times or whatever the amount of energy content in the hydrogen in order to produce deliver and store the hydrogen. And then here's another example where sensitivity analysis was critical, and again looking at the overall storage systems, the researchers, some researchers may assume that we can pull a vacuum. But you can see how that reduces or if you didn't pull a vacuum that would reduce your storage capacity. The fuel cell requires a certain pressure. So all of those are examples of the kinds of issues we're looking at in systems analysis.

Programmatically I'd like to highlight some examples of what we've been doing in the last year. We've been trying to collaborate much more closely internationally. We co-organized a conference with several countries and details can be seen at this website to see how we can really leverage global activities in hydrogen storage. We've expanded basic science, and Steve said this is the first time you'll see basic science projects in hydrogen storage at this review.

And we have various sessions devoted to hydrogen storage on Thursday of this week, and again starting from the ground up to see what sort of theory and simulation needs to be improved and can be used for the hydrogen storage problem. And then we continuously update our targets and ensure our strategic direction is consistent. I'd like to especially acknowledge the Freedom Car and fuel partnership hydrogen technical team who has been working very hard in support of this effort and these are just some examples of accomplishments in the last year.

We have a tool basically for researchers. We get questions a lot about what if we had a storage system that can use water from the fuel cell. And this tool would actually tell you how much water is available from the fuel cell. It will be posted on our website. We get questions on ammonia and we have a draft paper available on the website for public comments that really looked at the pros and cons of ammonia for storage. And then we continued to ensure that we're communicating with all the other parts of the system.

So really storage, what we decide for storage will have tremendous implications across the change for delivery for fuel cells and so forth.

This gives you a snapshot of two years of activity. You can see where we started. The centers of excellence just about a year ago, and some of our other programmatic activities. And I'd like to highlight that we have a call for proposals out now, and our plan was to introduce a revolving solicitation, so every year we can have the flexibility to assess where there may be new ideas from the community.

And I would also like to highlight a couple of key milestones for this year. Go/no go decision point on single-walled nano tubes and then an assessment of one of the approaches chryo compressed tanks to meet our target.

In terms of their proposals I'd like to highlight we have two now. Slide research, three proposals due June 7th, again this is the revolving solicitation, really looking at complementing what we're already funding through the grand challenge.

And then we have a larger solicitation, preproposals due July 6 from the office of science. These are for all the aspects not just hydrogen storage, novel materials for hydrogen storage is one component, and the total plan subject to appropriations is roughly 17 million in '07.

So in summary, our message is that new materials and concepts are critical at this early stage. We'd like to ask the researchers to ensure that you address volumetric capacity as well, temperature, pressure, kinetics, not just weight percent anymore. Basic science is essential. We need to develop a fundamental understanding that complements the applied programs. We also need to keep an eye on engineering issues, right from the start. And these are just some examples of essential capabilities that we're in the process of developing and we need to continue to develop as we move forward.

Finally, for more information feel free to contact any of us here. I'd like to advertise that we have a new position available in the hydrogen storage team, which closes May 19th. So if you're interested, please take a look at this website. I'd like to also especially acknowledge our golden field office counterpart who provided tremendous support for all the contract administration and our colleagues at the office of science, and especially acknowledge all of the researchers who really only in the last year or so despite all the uncertainties in funding and so forth have really made a tremendous start and tremendous contribution to the hydrogen storage program, and with that I would like to ask if the hydrogen storage team could please stand up and the hydrogen storage researchers for acknowledgment.

(Applause)
Thank you.
MODERATOR: Thank you. Our next speaker is Valri Lightner with the fuel cell team.

>> Valeri Lightner: I'm not going to be able to cover this additional information on the storage information team, so what's new. Good morning.

Today I'm going to talk about the recent activities of the fuel cell team. First I'm going to start off updating you on the technical challenges and also talk about our targets and the status of where we are towards reaching those targets. And then I'll talk about our strategy and also some recent accomplishments in specific projects.

And I just want to say I'm only going to have the opportunity to highlight a few of the accomplishments over the past year, but the fuel cell session runs starting this afternoon through 8:30 every night in oral and poster presentations. And so you'll have an opportunity to hear about some of the other accomplishments that I'm not able to highlight in my presentation this morning.

And listed on the slide are the members of the fuel cell team. Both as our headquarters office and at our golden field office. And I've only listed the representatives from the golden field office that are currently managing fuel cell projects. But I want to acknowledge the fact that while we're going through a solicitation like we are right now, it really takes the use of the whole team out there in golden to make the solicitation successful and to ultimately award all of the projects that will come out of that.

So our challenge is, the key challenge is for full cell systems remain cost and durability. So in order to be competitive with current automotive or power generation, whatever technologies, the fuel cell technology needs to compete with the technologies that are available today in terms of life sometime and price.

And so those are our key targets that we work towards. And in overcoming those, there are some other challenges that we tend to focus on, especially electrode performance, particularly the cathode, where we need to drive down the amount of precious metal catalysts that is used on the cathode.

Additionally, understanding the way that the water moves within the stack. While there's no moving parts for our fuel cell system, the water within the stack and within the balance of plant does move. And we need to understand the way that that water moves and where it goes in order to make sure the membranes are properly hydrated and that the water is appropriately taken care of during shut down so that you can start up again and ultimately optimize that performance.

So understanding the water transport in the stack is key for our start-up time and energy requirements, and also important in the balance of plan is understanding the water, thermal and air management, and how those are connected to the storage system, for instance.

Our key targets focus on the automotive targets, and again our program is focused on oil supply and having domestic sources that can provide all of our oil needs. And in order to do that, we're focused on substituting the gasoline that we use in our light duty vehicles for hydrogen as the fuel.

And so on the fuel cell system, the key targets again being the cost being able to compete with internal combustion engine. So we need to drive down the cost to about $30 per kilowatt. And we also need to be able to meet the lifetime requirements of about, you know, well more than 150 miles. So about 5,000 hours for the fuel cell life. And in 2010 we're working on systems that operate up to 80 degrees C. And then for ultimate 2015 targets, we'll be working towards systems that operate up to higher temperatures, possibly as high as 120 degrees C. So the lifetime requirements for the higher temperature operations will be more challenging.

So that's why that target is out a little farther.

In addition to transportation systems, there's other fuel cell systems that are also important to the program, both in power generation, portable power and auxiliary power applications. And these fuel cell systems are important to the program because they have a lower threshold for entry into the market. And as such these systems, the development of these systems can help establish both a manufacturing base, but also there's learnings, and the overall system in terms of balance of plan. And that kind of thing that can be applied to the transportation fuel cell systems. So it's important that we have some focus on these technologies as well.

Now, as Sunita mentioned, we have a good relationship through the Freedom Car and Fuel Partnership with our transportation partners, and we continue to try to engage the other industries, the distributed energy industry, the auxiliary power and the portable power application. But we're always willing to accept feedback on what the targets in those areas should be.

So we believe that this is what's required to be competitive with other technologies that your feedback on these is important to us, and also in the status of fuel cell systems towards meeting those.

This table is one example of our technical target tables. And I've chosen the overall fuel cell system, even though our focus is more on the component level. And in both our multi-year plan and also in the freedom car fuel cell road map, we have target tables that tell you you know where we've been and where we're going. So this is an example that shows the progress that we've made on systems. Now, industry is really focused on building these systems, but the results that at the component level have been important in order to enable these kinds of achievements for the full cell system. So you'll see over the past couple of years, since the hydrogen fuel initiative was kicked off, we've been able to decrease the cost of the fuel cell system by almost a factor of two.

And in doing that, two key things, two things that had been key to that had been driving down the amount of precious metal that's used in the fuel cell system and also being able to increase the power density while doing so.

For our lifetime for the fuel cell system, we have about a thousand hours right now, and we're looking forward to some of the data from the technology validation this fall that will help us refine that number a little bit.

And if you look at, I show the start-up in energy time to 50% power. Note that we're right now in the process within DOE of updating our multi-year plan. So our multi-year plan currently has this as being the start-up time to 90% power versus the 50%. So that's an update that we're in the process of making. That update has already been made on the freedom car fuel cell road map. And that update was a result of people that are in this room coming to me and saying, gee, I really think that 90% power is too stringent, is that really what it's supposed to be and then taking that back to the tech team and having discussions. So we do take your feedback and take that to the tech teams and we adjust when it's appropriate to do so.

If you look at the status in that, it looks like we've already exceeded our abilities in start-up time, but the next line, where it says start-up energy, you'll see that while we might be able to start up in a good amount of time, we're using too much energy to do that. And so when you look at the 2015 targets, it's really important that those are all met simultaneously in a single system.

But I have to note that our status, as much as we would like it to be in one single system, is not necessarily one single system. So there's different systems that are meeting different targets, and we need to get that to work altogether in one system to ultimately meet those technology readiness targets in 2015.

I'm going to highlight again the updates on fuel cell cost and durability, because those are so important. And you can see that over the past three years that we've made quite a bit of progress in driving down the cost of fuel cell systems. Now, this data is based on a study that's been done by kayaks. It's based on a half a million units per year production. And what this shows is that the stack is about 70% of the cost of the fuel cell system. So it makes sense for us to be focusing on reducing the cost of the stack.

The other thing that it shows is that within the stack, the electrode is almost 70% of the cost of the stack. Now, adjustments between last year's kayak study and this year concerning platinum costs are that we made a decision this year to go, since we were trying to baseline where the technology is today, that we would use today's cost of platinum and in previous studies that we've done we used the 100 year average.

Now, that impacts the cost of platinum by a factor of two. So we basically doubled the cost in this analysis. So that is a big difference from previous. In either case, the top three things that impact the cost of the fuel cell system are the platinum loading, the platinum costs and the power density. So we need to continue to focus on those.

The second sideshows the durability, and this is in the stack only. Now the way we come up with our status is sort of a consensus process within the technical team, where we look at data that's publicly available. We'll only use publicly available data and we try to come to some consensus number, because there are differences among the publicly available data.

So while the top graph shows that our current status for durability for a stack is at 2,000 hours you'll see the graph below, which UTC has given us permission to show, shows actually a lifetime under cycling conditions going out 4,000 hours.

So that's very promising results towards our 5,000 hour target.

The strategy like I said for the fuel cell team is to focus on the transportation application. And for the government, we're focusing our resources on components. Now, previously in the program we've been working on membranes, electrodes, membrane electrode assemblies, bipolar plates, balance of plant components.

So some of the new areas that are coming in through our new solicitation are work in gas to fusion layers and this goes along with understanding the water transport within the stack. Starting some work on fields, getting fields that can meet the lifetime requirements of the fuel cell system.

And we've also added a topic to look at innovative concepts. So this would be a full fuel cell system but maybe something that's not a cell, you know, maybe it's got a different architecture or minimizes components in some ways. So we're really looking for some kind of break through technology that can meet our future technical target.

And the solicitation that we have underway is currently in the review process. It closed on April 7th. But it's really been a milestone solicitation for the hydrogen program because it's the first time that we ran a lab call in parallel with competitive solicitation for the same topics. So the labs are competing against the same topics as industry in this solicitation.

So this is really a milestone for us and we're looking forward to seeing how this all plays out. There's about $100 million proposed for this solicitation over the next two to four years. We're looking at a time line to make selections in the fall.

So right now many of you in the audience are probably helping out with the peer review part of our solicitation process and we thank you for that. And we're going to be having our merit review committee in late June and then ultimately with the selections in the fall.

We hope to have projects started early next calendar year.

And also important to our strategy is continuing to focus a small amount of resources on other fuel cell systems. And, again, the reason that we want to do this is to help develop a manufacturing base and to provide the learnings for systems, systems level learnings and balance of plant components, but also to help the public become more aware and more familiar with fuel cell systems. So it's not an out there kind of technology, but it's the technology that they're used to and they're willing to accept and use and it's familiar.

So advancement in the use, other fuel cell systems, distributed power, the auxiliary power and affordable power are going to be important ultimately for the success of fuel cells use and transportation.

Our budget. Our fuel cell budget has been about 60 million for the R&D portion and request for the past few years. And you'll see as I've been stating that our focus has been on the stack components which is the yellow bar in the middle.

So that area is growing over the years. Another thing that you'll notice by this graph is the top bar, the top greenish color bar is the process area and that bar has been going down over the last few years as a result of the decision in 2004 to discontinue our work on board fuel processing. So the current work that remains in the fuel processing is focused on stationery applications. So use of natural gas or propane reforming that for the full cell system, and our request for transportation systems and for distributed energy systems has remained relatively flat.

And the auxiliary power and portable power is currently funded out of the transportation systems bar, so the reddish bar has been remaining flat in our request.

So I'm going to highlight a few of the recent accomplishments of the fuel cell activities that are really giving us excitement that we're taking steps in the right direction to get down that path to the technology readiness. And the first area that I mentioned that was really important was we work on our cathode catalyst and we need to use less catalyst to drive down the cost while still maintaining performance.

And so we're looking at two different approaches. The first approach is platinum alloy catalyst, and we're recognizing in this presentation some of the work of 3M and Brookhaven as being able to achieve state of the art mass activity for platinum alloy catalyst at 3M with some innovative architecture that they have that uses whisker structure as they call it which increases the surface area.

While we still have about a factor of two to go on the mass activity of these platinum alloy catalysts from 3M we're very encouraged that we're moving in the right direction and that there's a pathway to get to these higher activities. And they've been able to do this while also increasing the lifetime of those catalysts.

Not only are they able to increase the activity but they've also been able to show that they have an extended lifetime on those catalysts and some of the work at Brookhaven.

(Audio difficulties
We've had a couple of achievements both at the (inaudible) and at the University of Carolina. At Los Alamos, the partnership with University of New Mexico, they've been able through a catalyst preparation method to increase the amount of catalyst that they can put on the electrode. So they've increased the thickness by ten times without impacting the mass transfer of oxygen and air to get to the active particle sites.

And this is going to be really important -- it is a really important finding in ultimately trying to use nonplatinum catalyst, because the idea is that you can use more catalyst than you would a platinum catalyst, because the cost is so cheap. And so this is an important finding for continuing to move the nonplatinum catalyst work forward.

And recently the University of Carolina has actually identified a carbon-based catalyst. No metals at all that has activities that are approaching some of the other nonplatinum catalysts and that's been very encouraging.

And in addition to this activity, it also tends to reduce the peroxides that are formed. And peroxides tend to degrade the MEA and ultimately reduce the life of the fuel cell system. So it's important to reduce those.

The work at Oak Ridge National Lab on characterization they've been using transmission electro -- TEM imaging to look at a nano scale, sorry drawing a blank there, to look at the nano scale of the particles within MEA. And they've been able to look at the MEA both during manufacturing and also during operation and learn things about what happens with the migration of platinum catalyst and also understanding what's happening with the membrane, the ionomer, and the platinum and to identify conditions that have caused the platinum particles to become in areas where they're no longer active.

So being able to understand this characterization and take that back to the design of the MEA is really going to be instrumental in helping us get the best use out of those platinum catalysts that are or nonplatinum catalysts, whatever they are, but making sure we're maintaining their activity.

Additionally, in characterization area, NIST has recently upgraded their neutron imaging facility. And they've been highlighted in past years at our annual review about the importance of the work they're doing on realtime imaging of the water in the stack and understanding how that migrates and where it's, where the water is formed and ultimately to help optimize the fuel, the operation of the full cell system, the stacks.

And this work in understanding the movement of the water also ties into the management and the freeze conditions. So if we can understand where the water is and how we can optimize where it goes or how we can operate the system in such a way that we engineer solutions to the water management, that will help in ultimately in developing a freeze tolerant fuel cell stack.

And Argon National Lab and some of their work on freeze has discovered that it's important to look at the specific gravity of the ice that forms within the fuel cell stack. And they found that if you can keep a specific gravity greater than point 5, then you're able to to start up the fuel cell without outside assistance. And so that's what the graph on your left is showing, where the green curve goes down because they were not -- it's less than.5. It's only at .2 specific gravity and they were not able to start up the system with that. So that's going to be important in helping to solve the issues of freeze start.

And the work at Los Alamos has shown that while some conditions are important but just as important is the rate at which you freeze the stack.

So if you can control the rate of freezing, they have shown that you can stack survive conditions less than minus (inaudible) C. It's really in the management of how that freezing occurs.

And there is an example of a picture where you do see some delamination, but that was at freezing down to minus 80 degrees.

And those results really were, have been key because previous findings were that you couldn't freeze a stack at minus 40 without causing this delamination.

Just a couple of other highlights in the recycling area. While there's plenty of platinum resources in the ground to support fuel cell systems in the future, the economical extraction of that platinum is challenging, remains a challenge. And so we feel like ultimately for fuel cell systems to be competitive, they'll have to depend on recycling platinum.

So we have two projects, one with Ion Power and one with Englehard looking at recycling the platinum, and the project with ION power is looking at recycling or reusing the membrane material, possibly for an MEA but possibly for other uses as well.

And some recent work at Dupont and UTC in the membrane durability area have found that there's a coupling between both the mechanical degradation and the chemical degradation. They've been working on developing accelerated testing methods to identify both mechanical and chemical degradation, working with the U.S. Fuel Cell Council on that and what they found through the process through the swelling that causes some of the mechanical degradation, that actually the cracks and the defects that are caused in the mechanical tend to accelerate the chemical degradation as well so they really need to be understood separately but the coupling needs to be understood as well.

And they made some, you'll hear later about their (inaudible) and how they've been able to use that knowledge to increase the life of the membrane.

And this is just for more information, the fuel cell team and you'll see more of them in the fuel cell sessions this afternoon.

MODERATOR: Thank you, Valri. We'd like to invite you here in the audience and those on the webcast to ask questions of Sunita Valri and also of Tim Fitzsimmons from the Office of Science. I vine it you to ask hard questions. Technical or programmatic. There are wireless mics on both sides. Both sides of the room.

Any questions from the webcast? How do we get the questions? No questions from the webcast?

No questions, all these people and no questions?

<QUESTION>: Certainly not.

Moderator: Scott. All right.

<QUESTION>: I'd like to ask Tim how the Office of Science is integrating into this program and what efforts are being made to make sure that what's generated in fundamental science integrates well into what's needed in applied science.

>> In answer to your questions, and please get back to me if I don't hit all the points, we're having, certainly organizing part of the meeting this week, particularly the theory session on Thursday to talk about both fundamental and more applied work in the theory area and how

it might apply to the relevance of questions in this community. And also on Friday there will be presentations as well as the bulk of the presentations on Friday. Thursday there will be a poster session and things from the science community highlighting not only the research but feasibility that the basic science side of DOE house is developing, that are indeed in some cases already have characterization of materials that might be of interest to the fuel cell and hydrogen communities. And so the idea is to highlight our capabilities and to provide an opportunity for people who have questions to come up and talk to our people and say, okay, this is where we might be able to help you or you might be able to help us and solve collaborations.

So that's one level of answer. A second level question is the planning that goes on between my colleagues the basic energy side of the house and my counter parts in EE and other parts of the Department of Energy. And indeed as other federal agencies and there are a variety of coordination mechanicisms that existing including at the OTS level where we meet monthly and across the federal government to talk about our plans and opportunities and make presentations on what we're doing and presentations of what other counterparts of the federal government are doing. There's also a planning process for future (inaudible) which is done coordinated at high level and the management change of both organizations. So it's going on in a variety of fronts and we're hopeful that it will lead to a very well integrated effort and effort that we're usually supporting in all ways.
MODERATOR: Thanks, Tim. Yes.

<QUESTION>: What levels of efficiencies are you achieving with these fuel cells?
MODERATOR: Can you identify yourself, please.

<QUESTION>: Merle King, national headquarters.
>> Our current status for efficiency reporting for transportation is 59%. And again that's not necessarily in a system that meets some of our other targets. The efficiency that was used in the kayaks analysis were costs 55%.

<QUESTION>: Thank you. (No audio)
>> But the new solicitations were to solicit completely new concepts that were not focused on high pressure tanks.
MODERATOR: Any other questions? We've gotten questions lately in storage about the use of ammonia as a hydrogen storage medium. Maybe Sunita you can talk about that a little bit.
>> As JoAnn said we've received questions and through the freedom fuel partnership technical team including experts from industries and the national labs and so forth, we've come up with a paper, a technical paper that outlines the advantages and disadvantages of ammonia. It's available on our website. Hydrogen.energy.gov it's available for public comment and we welcome all your suggestions, but basically the message was that as long as you're looking at conventional fuel

processing of ammonia for on board storage, so in other words conventional crackers, where you need over 500 degrees C to get the hydrogen out, and you have many of the issues that are similar to on board fuel processing of gasoline for which we had a no go decision point. And so we're at plus you have the issue with pen fuel cells of ammonia tolerance. So the many issues related to ammonia at the present time were really not looking at ammonia for on board storage. I'll mention that the delivery team is investigating ammonia and will be investigating ammonia as a potential carrier of hydrogen. But for the on board storage part of the program at the present time we were really opening it up to other completely new concepts and materials-based technologies.

If, of course, someone has a break through in terms of generating hydrogen from ammonia, solving all the other issues like ammonia, tolerance to ammonia from the fuel cell side and meeting all the other requirements, then especially through the basic side there would be opportunities.

But again to summarize that the present time the storage portfolio, the storage budget was really geared towards completely new concepts.
MODERATOR: Okay. Any other questions? Questions please identify themselves and their affiliations.

<QUESTION>: I have a question about a fuel cell technology, talking about improvements. Just wondering, for example, for lowering the cost and the (inaudible) ability, are you using the same system or it's just improved independently?
>> It happens in the same system, all the targets need to be met simultaneously in the same system.

<QUESTION>: Okay. Thank you.

<QUESTION>: Tom Benjamin from Argon, you did a study that's 500,000 units per year. Does that assume certain manufacturing technologies? Do those exist today? Is DOE looking at what might be (inaudible) in manufacturing?
>> Maybe JoAnn should answer that question.
>> We have initiated a manufacturing -- well, we held a workshop in July to address the R&D challenges related to manufacturing for production storage and fuel cells and we have developed a road map which we had on our website open for public comment until April 24th. So we're now looking at those comments and we'll update the road map.

We have requested a small amount of money in the '07 budget to start a manufacturing R&D effort and initially we're focusing on the transition technologies producing hydrogen from distributed natural gas and from small scale electrolizers, primarily compressed tanks for storage although we will consider materials if they're at a relatively advanced stage and then for fuel cells. What we do with manufacturing R&D will depend on our appropriation, of course.

<QUESTION>: Merle King, back again. Have you dropped all the work you had been doing before in thermal use of hydrogen such as internal combustion engines or other cycles. I know several years ago you were still looking at that and in connection with that what would be the possibility of looking at ammonia, not for fuel cells, but for internal combustion engines? Would this be an interesting combination because you could get quite a bit more density of storage with the ammonia.
>> Our vehicles technology office our sister office within DOE is doing research related to hydrogen powered internal combustion engines. So, yes, there's a small amount of work going on in that area. They are not looking at ammonia at the present time.

<QUESTION>: Thank you.

<QUESTION>: Yeah, these storage technologies all are centered around transportation or small on site storage. My name is bud (inaudible) I'm with the Sacramento Municipal Utility District electric utility in California. And we're interested in much larger volumes of hydrogen and if our hydrogen is going to come from, say, Syngas or other large producers of hydrogen are we looking at cavern storage or other large, large storage facilities, seed money in there? What have we got?
>> Thank you for the question. And I really focused just on the on board hydrogen storage part of the program, and later this morning Mark Paster will talk about the delivery components, and off board storage is included in that and (inaudible) storage for example is also included in that.

<QUESTION>: Thank you.
MODERATOR: Any other questions? Yes.

<QUESTION>: Maria (inaudible) from DC. My question is directed towards Sunita. What is the pressure temperature parameters for chryo compression.
>> For compression or --

<QUESTION>: Chryo compression?
>> With chryo compressed technology, we're looking really to couple the benefits of coal technology at liquid nitrogen temperatures at 27 Kelvin, and right now we're looking at about 5,000 PSI as the option for chryo compressed. We would not need to go to the 10,000 PSI but still benefit from enhanced capacity.

<QUESTION>: Jeremy Meyers from UTC Fuel Cells. On the efficiency or the overall vehicle targets have there been any looks at what hybridization or even plugged in hybrids might do to change the relative importance of some of these targets for the fuel cell system?

>> We've had some discussion about that but you start to get into the proprietary area when you talk about hybridization strategies, so the discussions don't go too, too far. So as a result of that we haven't changed, for example, the efficiency target as yet but we're keeping it on the table.
>> I would add our sister office is freedom car, vehicle technologies office had a workshop about a week ago on plugged in hybrids and batteries and so forth. So this is kind of an emerging area that we'll be looking more and more at in the future and we'll know the implications and be able to better answer your question in a little bit.
MODERATOR: Any other questions? Any webcast questions? Okay.
Sunita, Tim and Valri will be up here --
>> Just a short follow-up to the hybrid question having driven a couple of these fuel cell cars it would be great if we could just roll out and start the fuel cell underway, because otherwise people are sitting there looking, you know at the thing dripping out the back and why aren't you underway yet. It would just be great to get in roll off on battery and have it go underway.
MODERATOR: Thank you.

The speakers will be up here for a few minutes if you prefer to come up and talk to them directly. We'll now take a 15 minute break and reconvene at 10:15, 10:20.
MODERATOR: We're going to hear from four speakers during this next session. We'll have the presentation on coal-based hydrogen, nuclear-based hydrogen, hydrogen from distributed natural gas and renewables and hydrogen delivery. And then we'll have a short panel discussion where we'll open it up to questions from the audience and the webcast.

The panel will include Tim Fitzsimmons from the Office of Science. Our first speaker is Lowell Miller from the Office of Fossil Energy.
Lowell manages programs and liquid fuels coal-based hydrogens and (inaudible) sequestration.

>> Okay, JoAnn, good morning, everybody. It's a pleasure to be here, and we will get started. This morning -- there we go. I would like to take my time this morning and rush through a number of things that are relevant to the hydrogen program. The hydrogen control program is part of the administration's hydrogen fuel initiative.

There are a number of things that I would like to try to get done in ten minutes. So I'm going to go rapidly through things like the pathways, a little bit on the technology, budget, and then some of the old time accomplishments and what we're doing in '06.

What that all means is you better be good speed readers because we're really going to take off. I'm going to go back and revisit this first slide. Principally because of changes in the market. This first slide shows the hydrogen from coal pathways and it is distinctly different from what it was from when we started out this adventure way back in '04/ '03, simply because we were talking about hydrogen from coal at that particular time on the blue up on the top which is pretty much a standard approach to the distribution or to the generation of hydrogen from coal. And it follows pretty much what's being done today except today it's natural gas.

However, since we got this program started, the oil prices came as far as prices are concerned, and we now have a very strong interest in looking at coal at liquid fuel from all sources of all fuels from all sources, and now we're beginning to see in the juncture as far as taking care of the high price of natural gas.

Natural gas and its (inaudible) across is working a number of small owners and utilities to revisit their power source or energy. And so they're beginning to look at natural gas.

For us, for those of us who have been in the (inaudible) business for some time it's really interesting, because we're recycling. We're going back and again looking at (inaudible) gas. If you look at the second line from the bottom, the alternate fuels, that is something that is being implemented at this particular time by a number of utilities, looking at their problems for natural gas prices.

Moving on, I'm going to talk a little bit about the challenges and point out that the natural gas, the hydrogen from coal program has two other aspects which you're going to hear a little bit about later on, and in that you will hear a more detailed discussion of the sequestration program and you'll hear more on FutureGen both are closely tied from hydrogen from coal simply from the type of technology that's involved.

Looking at the technology and demonstrating why that is so, when we got the challenge of becoming a hydrogen from coal as part of the hydrogen fuel initiative, we had a very strong coal conversion program ongoing at that particular time. We spent a lot of time looking at that particular program, deciding how we best fit into the new program hydrogen from coal.

The blue box shows the result of that analysis, and that is the area in which we're now looking at as far as where we're focusing our R&D activity. The others are major programs that also exist in the Office of Fossil Energy that we support in one way or another. In particular, if you look at the solid oxide fuel cell, it's also very definitely a coordinated activity between what we're doing and the hydrogen from coal and what they're doing in the solid oxide fuel cell.

This year we're now looking at this number of projects as we look towards the program. This slide will give you a chance to look at the areas that we're focusing on, the primary concentration effort. And you can see that one of the major areas that we're looking at is membrane technology. We're very excited about membrane technology and it's becoming a very primary focus of our programs not only in the hydrogen from coal, but the coals to liquid program as well as some of the sequestration activities and of course we're beginning to look at gas security as well as being able to convert or do a number of steps in a single reactor.

The hydrogen from coal, what we're trying to do in this particular program, and these are the major goals that we have in place, is to, by 2015, demonstrate a 60% efficiency. Zero emission coal fuels. Hydrogen and power coal production facility. You will hear more about this as we begin to talk to, as Joe (inaudible) gives you his presentation on FutureGen and showing how it all ties together.

And then the alternate hydrocarbon pathway has become considerably more important than it was when we started out this particular activity. And this is as a result of an emerging interest on the part of the Department of Defense who is now looking at a way to solve some of their fuel problems as they look towards the future and as they tie in the concept of energy security.

This particular, their interest is now leading us down a pathway looking at some very interesting carbon conversions or carbon compounds that are coming out of some of our catalyst work and leading towards their objective of one fuel.

Some of the FY '05 accomplishments, looking at this I hate to even start listing the accomplishments because it's certainly not possible to list all of them. But there are one or two that we'll call your attention to show how much progress has been made in that brief period of time. And I would ask you to look at the third bullet down or the last, next to last bullet, because in this particular project, we've been very successful in trying to accomplish what we refer to as process intensification, where that's looking at ways that we can combine as many single steps into one major step and that's gained the efficiency as well as the cost savings that are associated with being able to do that.

This is one project that has moved a great deal along that pathway. Others that are coming down the line or that we have gotten on schedule, we're looking at the ones from (inaudible) Power Corporation. Looking at combustion gas cleaning concept and a moment aside from that gas cleaning (inaudible) we thought we had conquered as part of overall coal conversion program. So when we got into the hydrogen from coal program and started to look at the requirements, security requirements of the hydrogen required for fuel cells, we began to realize we were not even close with the technology that we were using to accomplish the cleanliness objective of power plants. So we've gone back in and are looking at that with a great deal more intensification on reducing contaminant levels down to the lowest possible contaminant possible.

And the novel hydrocarbon lease catalyst, once again it moves into our alternate pathway for the delivery of hydrogen from the plant to the consumer or the distributor. Once again, this focuses on purity, as well as looking at the catalyst and the fidelity as well as the characteristics of the catalyst.

Switching briefly to the 2006, we're now deeply involved in knowing exactly where it is we are and what we're trying to do. These are four new projects that we have just recently started. They're well underway. Once again, it's the reduction and oxidation of iron-based catalyst. Those were involved in catalyst know the advantage of getting an iron base rather than a noble metal catalyst. We're looking at preprocessing of coal. This gets into looking at the problem that we have on associated with sequestration and that's trying to get ahold on it early in the process. Arizona Public Service is now generating hydrogen from coal to solve this problem with natural gas. And surprisingly they've got a unique hydro gasification or gasification through high BTU process which we thought we laid to rest about ten years ago. But it's coming back and we're seeing a lot of very unique ideas in the conversion of coal to a substitute natural gas and finally West Virginia university has a number of our products and they're looking at various pro products that will help compensate for the cost of the hydrogen product.

FY 2006, we again released a couple of solicitations. One on central production and when I use the term "central production" we're using the term "big central facilities" as opposed to just distributed production, which means production at, well, the name certainly tells what we're trying to do with that.

This will be on polishing filters and process intensification once again. This one is still open, closes June 8th, 2006. The alternate production and utilization just did close. But we were looking for a number of projects that would help us in the conversion.

In closing, I would offer you the opportunity to take down this website. This website is leads you back into the Office of Fossil Energy. It's a very strong and good website. You can then go from all of the various sites into any one of the programs that you feel that you want to look at as far as our program's concerned, and most of all it will take you into our hydrogen from coal program. It's on the website, and it will give you a detailed analysis of what projects we're doing, what technologies we're pursuing, what goals and objectives are and why we're in those particular technologies.

And with that I thank you for your attention and for being speed readers. Thank you.
(Applause)

>> Thank you. Our next speaker is Carl Sink who manages you a nuclear-based hydrogen program.
>> Good morning. My name is Carl Sink. And I'll talk to you briefly about our progress over the past three years for the nuclear hydrogen initiative. And some highlights of where we're at and some of our accomplishments.

Started in fiscal year 2003, it it wasn't called the nuclear hydrogen initiative but it was an initiative to look at hydrogen production looking at advanced nuclear reactors.

In 2004, we got our first budget appropriation for something called the nuclear hydrogen initiative, and in the past couple of years we've focused on process development for sulfur iodine cycles and high temperature electric troll sis as well as modeling and development of high temperature heat exchangers. This year, in 2006, our program focus has been on constructing integrated laboratory scale experiments for the software iodine cycle and high temperature electrolysis process. We're looking at process development for hybrid sulfur which I'll mention in a little while and the calcium bromine cycle and the identification of some promising alternative cycles for hydrogen production, both nuclear energy.

We're also looking, continuing to look at the supporting technologies, membranes, catalyst, materials and heat exchangers which are needed for these processes.

Our overall goal is to demonstrate commercial scale economically feasible production of hydrogen using nuclear energy by the year 2020. And our project target to support this goal by 2008 we will have operated our laboratory scale (inaudible) chemical and electrolytic processes to determine the feasibility of coming them with a nuclear reactor this will lead to a 2011 decision which is mandated by the Energy Policy Act to select the process for coupling with an advanced nuclear reactor which would be the next generation nuclear plant.

By 2014 we would build a pilot scale demonstration of thermochemical hydrogen production for use of nuclear reactors then by 2020 finally have an engineering scale demonstration.

So our scope to review covers thermal chemical cycles. High potential for high efficiency production. Have a large scale and the technology is relatively immature still. High temperature electrolysis faces much of its technology on what its been developed for solid oxide fuel cells, we have a lot of coordination for solid oxide fuel cell group. The high temperature electrolysis promises higher efficiency than conventional electrolysis. The systems interface group looks at the interface between the nuclear reactor system and the hydrogen production process as well as looking at balance of plant equipment, the infrastructure needed and support facilities and what we need for our experimental demonstrations.

Finally, in the technical integration area we're doing system studies to help focus our research and to provide coordination necessary for the complex program we're operating.

In thermal chemical cycles, some highlights of our progress. We have collaboration between the DOE and the French CEA under an international nuclear energy research initiative that's been going on for about four years. This is moving toward the beginning operation of the integrated lab scale experiment in fiscal year 2008. For the hybrid sulfur cycle led by Savannah River National Laboratory the research focus is on development of a sulfur dioxide water electrolyzer, which would be used in conjunction with the sulfuric acid decomposition part in an integrated lab experiment for calcium bromine the work that's been done at Argon National Laboratory is in support of a go/no go decision on the viability of this process coming up this June.

And an alternative chemical cycles, there's several cycles that have high efficiencies or they could operate at lower temperatures which might broaden the range of advanced reactor type to operate with. It's been done in conjunction with sulfur hydrogen research which looked at alternative cycles and we've got a subcontract right now through the universities to analyze and evaluate the most promising of these cycles.

In the area of high temperature electrolysis, this has been spearheaded by the Idaho National Laboratory with support from Seramtech, Argon University of Nevada Las Vegas and Oak Ridge National Laboratory. As I mentioned before it's been closely coordinated with the DOE solid oxide fuel cell research. We're looking at cell electrode materials with improved durability for the variable cell environment that's being developed.

Also looking at high temperature inorganic membranes, the work being done at Oak Ridge for separation of hydrogen from the seam that's developed.

And this improved overall production efficiency.

One of the major accomplishments over the last year is during January and February of 2006, we did a one thousand hour continuous production at Idaho national laboratories producing greater than 100 liters per hour of hydrogen.

Argon national laboratories also supporting this effort with some computational fluid dynamics work, modeling the integrated performance of the hydrogen production plant and the reactor plant. And their current focus is looking at the analysis of individual flow channels within a solid oxide electrolyzer cell, looking at temperature, current density and local hydrogen production.

The systems interface area, we look at all the issues related to coupling the reactor to the hydrogen production process. High temperature heat exchangers, heat transfer fluid, be it molten salt or helium, material with construction, safety issues, the environmental requirements, the licensing requirements, oxygen and hydrogen handling requirements.

Our current focus has been on the sulfur iodine and high temperature electrolysis heat requirements and transfer of heat medium. One of the accomplishments moving this forward is establishment of a partnership between universities, private industry and national laboratories which is led by the University of Nevada Las Vegas Research Foundation. They've done a lot of work to identify candidate materials, to do coupon tests on those materials, and to perform physical property tests.

Technical integration, the major role is to provide the integration to keep all these activities and the systems analyses going. The systems analysis group coordinates with the generation for, the methodology working group as well as the EEREH 2 A working group. Our current focus on identifying nuclear-based hydrogen requirements, evaluating configuration options, developing criteria and framework for comparison of the process options, looking at the required nuclear hydrogen infrastructure, and also investigating technology implications of potential applications and implementation strategies.

Our program schedule shows we'll be doing the lab scale experiments out through October 11 to look at the technical feasibility of the processes we're examining. Then we'll move on to pilot scale experiments to look at economic feasibility, and finally make a decision as to whether to carry forward a thermochemical process or an electrolysis process for engineering scale demonstration or possibly both.

One other thing I'd like to highlight is a solicitation that we recently released for a feasibility study. In the Energy Policy Act, section 634, solve for two projects to demonstrate commercial production of hydrogen at existing nuclear power plants. And this is to be preceded by an economic analysis of such production. Nuclear hydrogen initiative as had proposals from industry to perform a feasibility study which would inform the required economic analysis.

The purpose of this is to obtain analysis of the economics, the regulatory requirements and the environmental impact of hydrogen production at existing nuclear power plants. And this was announced on April 13th and the proposals are Dubai June 5th.

In conclusion, I would say we're progressing on schedule to meet our milestones and our program goals. The budget support for our program remains strong, and you can find more information on this through the hydrogen.energy.gov web portal which gets you to all the hydrogen programs. Thank you.
(Applause)

>> Thank you, Carl. Our next speaker is Pat Davis. Pat manages our safety cares and standards work in the hydrogen program and he also leads the production team developing hydrogen from distributed natural gas and renewables. And he's going to talk about the latter.
>> Pat Davis: Thank you, JoAnn. As JoAnn mentioned I'm going to be speaking about our EERE hydrogen production R&D and our team members are Arlene Andersen, Peter Devlin, Roxanne Garland and Mark Paster, who are all here in the room. I won't ask them to stand up since it seems like the hit rate of getting people to stand up is pretty low. Golden field office managers are (inaudible) and Dave Peterson and Jessie Adams. And like other folks have mentioned before me, certainly other people at golden has helped us out along the way.

I want to start with budget because budget has had a significant impact on our hydrogen production activities. You'll notice that we've had good request levels, 2004, 2005, 2006, and even in 2007 request has continued to go up. However, the available funds for the program have been significantly lower. In fact, if you were to sum '04 and '05 and '06 requests and look at the difference between that and available funds it's a shortfall of almost $50 million, recognizing that when I use the term "available funds," I'm not including congressionally directed products.

We have attempted in some cases had good success in working a number of our technologies with the congressionally directed projects.

So what happens if you have that kind of budget shortfall you have to make some decisions, and our decision has been to focus as much as we can on near term distributed production technologies, that support the 2015 technology readiness milestone.

Now why do we do that? The reason is simple. Distributed production pathways basically delaying building a hydrogen infrastructure if you want to roll out vehicles in the 2020 time frame and you don't have the established infrastructure to do so from a centralized basis, you have to do so on a distributed basis. And these are the technologies that have promise in doing that. So I'm talking about natural gas, distributed reforming, renewable liquid reforming and distributed electrolysis, all of which has had significant effort and some progress to report today.

That doesn't mean that we're ignoring the long-term. After all, the end game is about diversity. It is about sustainability and renewable technologies. So we've continued to look at, and to the degree we can, support central electrolysis, central biomass applications, photo electrical chemical, solar high temperature thermal chemical and biological pathways (inaudible) fermentation and biological.

Now, looking at the distributed natural gas pathway, this year we have been pursuing a independent cost review. We have a technical objective to reduce the cost of distributed production from natural gas to $3 per GGE. That's the gasoline equivalent, by this year using our best laboratory technology. This isn't technology that's been completely demonstrated or validated in the field.

And $3 per gallon of gasoline equivalent would be demonstrated in our technology validated program in a couple of years, by 2009..

To do this independent cost review, we started by a review strategy to, that has concentrated on the hydrogen production tech team looking at each one of our current projects with project reviews and visits and helping to gather data that would then be handed over to the independent assessment.

That independent assessment includes experts that were gathered and by the way the independent assessment is being managed by our systems integration group at national renewable energy laboratory and so they gathered these experts to look at this data and they're going to be put back to us on where we are on a cost basis.

The project's reviewed and supported this. And the current projects that we have on the way that include cost share, air products, GTI, BOC, H 2 gen and GE. Independent review panel is doing their work right now. They'll be concluding their work shortly and these results will be available this summer, and of course they'll be published on our website also on our, in our 2006 annual report, which will be due out in November.

Now, to move on to some accomplishments. Specifically in distributed reforming I mentioned our air products and chemicals project in which they develop an integrated fueling system. This is located at state college Pennsylvania and dispenses and stores high (inaudible) hydrogen at a cost approaching 2006 target. When I say that it means the underlying technology that is represented by that system approaches our 2006 cost. It doesn't mean that particular system produces hydrogen at $3 per gallon of gasoline. Because it's a one of a kind system.

They achieve their gain through improvement through their purification technology, through improved reactor design that includes both materials that are, that comprise that reactor and the catalysts that do the work, and then finally integrating that system into a complete integrated system. Secondly, we'd like to highlight work at Reliant Energy Systems which have a very interesting technology, unique acquiesce stage reforming technology, which is used in reforming of bio sugars, and they've had great success in producing hydrogen and doing so on a basis where if you compare to gas-based technologies the amount of hydrogen produced per amount of catalyst has been quite impressive. So we're very interested in that technology as a way to produce hydrogen in a distributed way from renewable resources.

Mentioned a few electrolysis highlights. First of all we're very excited about the formation of the hydrogen utility group. Also commonly referred to as the hub, and in this group the utility, the eight bounding utilities came together to look at hydrogen production technologies, to look at what needs to be done as far as utility involvement and the development of technologies that would, could be used in the future by utilities to produce hydrogen, and so this is a great start of key stakeholders to work together in an area that needs attention.

Secondly, analysis effort, we've looked at the H 2 A model has been very important to the hydrogen production team. We've used it across the board. One of the early things we did was look at wind electrolysis and so we used H 2 A models to look at wind and that analysis is complete, and didn't really change our opinion about -- remains a strong renewable pathway for hydrogen production. But we also are using it we're continuing to use it now to refine our technical targets for different types of electrolysis, both distributed and central applications. To date we're not seeing major changes in those targets. But it's important because it will help us both refine the target and will also help us point us in the direction of the R&D we need to be doing.

Third bullet is the establishment of the natural renewable energies laboratory and Excel cooperative research agreement. They're working on collaborative R&D to characterize integration issues, large hydrogen production systems with wind technology so that system is going to be put at the (inaudible) wind facility. We're very excited about that. The fourth bullet there is the gainer electrolysis system. Been very successful on lowering costs they've lowered costs by more than 50%. And they've done that in a variety of ways. But 1 Significant Way is by reducing the part count required for their systems. And an example there is the (inaudible) support structure count has been reduced by more than 50%. Finally like to mention that the solar and wind technology report to Congress was a requirement EPAC ha delivered to Congress is available on our website the website other folks have mentioned www.hydrogen.energy.gov. And that report details the solar wind hydrogen production pathways.

Now, I only have two more slides and I'd like to devote those to along the term "technologies." First high temperature solar. Over the last two years we've evaluated and down selected from over 350 cycles originally down selected to 14 based on literature analysis and initial thermodynamic analysis. Three of those cycles have eliminated based on laboratory work, and we now have seven cycles under active R&D. If you do your math 14 minus 3 does not equal 7 and the difference there is we have a couple of cycles that were of the same family. So because of limited budget, we've just focused on one. We have a cycle or two that involves you know some pretty nasty elements we've worked on in the latter, and we temporarily delayed that work.

Then down below initial systems are designed and costs estimated. Here's another H 2 A success story in that we've used H 2 A to look at high temperature solar technologies and are pleased to say that preliminary analysis have indicated that this technology can be cost-effective in the long-term. And I think more importantly here the success story is that analysis has pointed us in the direction of the R&D review we need to be doing to get where we need to go.

And then finally I'll talk a little bit about our biological and photo electric chemical work. In the biological area, to be completely honest, we've had some severe budget constraints that have restricted the amount of work we can do there and that has resulted in incremental partners. You have continue work to do in this area, and there in the first bullet basically what we've done is out of three primary organisms we identified we completed the characterization of one. We've also continued to improve the oxygen tolerance of these organisms.

And under PEC for the electro chemical, we've welcomed new quotes resistance, high efficiency tandem cell for PEC based on a lower cost material system. We've also achieved 3.1% solar to hydrogen efficiency and oxide base PEC device knowing in 2003 the efficiency was under 1%.

And this device will not get us to the final target we need to be, but we're using it as a vehicle to point us in the right direction with other compounds.

And we also continue to work closely with basic energy sciences in this area to leverage their activities and accelerate our progress hopefully when we can get a more robust program established.

That's all I have today. Thank you very much. I appreciate your attention.
(Applause)

>> Thanks Pat. Our last speaker is Mark Paster, who manages our hydrogen delivery work.
>> Good morning. It's a pleasure to have the opportunity to talk to you at least for a short time about our hydrogen delivery program.

The scope of this program is from the end point of production, and that production could be a large central plant or it could be a distributed unit right at a refueling station, and from there all the way through the (inaudible) so in the central case it includes transport and distribution, and in both cases it includes the operations at the refueling side itself, which produces hydrogen would be compression storage desensing. It turns out those refueling operations are at least half the cost of delivering hydrogen to a vehicle.

The overall target for delivery is you get it down to less than $1 per gge by 2017. That target used to be 2015. But because of shortfalls in funding, we now realize we can't achieve that until 2017. Having said that, we are still focused on getting it down to less than $0.40 per GTE for the refueling stations themselves by 2015 to stay on the critical path and demonstrate distributed hydrogen production to meet our targets for that key decision point in 2015.

Three primary ways to deliver hydrogen: Gaseous hydrogen, chryo gen Nick hydrogen and use of novel carriers, you heard about this earlier. A one way carrier maybe not so novel is ammonia. Novel two-way carriers i.e. liquid carbons that could be easily and hopefully efficiently and inexpensively hydrogenated and dehydrogenated and used the carrier to transport it to drive down delivery cost. One can imagine using solid carriers in a delivery infrastructure.

Or we could use solid carriers for just part of a delivery infrastructure specifically off board storage.

When one looks at those pathways more deeply, it becomes quickly apparent that there's a lot of components that you need to have working for you in hydrogen delivery infrastructure.

The ones over here on the left and the ones in red are the ones that we're funding, research and development on, to the ones that are the key drivers in terms of both performance and reducing the cost of the cost (inaudible) I showed earlier. The ones on the right still need some development effort and we're counting on the industries to do that, we're counting on the technology over here to pull through and get the other components operating where they need to be operating at.

The budget. The program just got started in 2003 with planning in 2004 was really our first budget request. And we, as you can see, we've increased the request significantly every year to get the support program off the ground and running.

Unfortunately, with the congressional appropriations that we actually received, the funding in this program really has been rather limited. We have however a research project, unfortunately very few of them are funded.

Despite that, we do have some accomplishments. First one I'd like to talk about is the H 2 A delivery models and there's actually two of them. One is a components model and all the components I showed you earlier are in that model where you can look at the actual cost and energy efficiency of those single components and their contribution to cost and energy use in an overall infrastructure.

The second model is the scenario model which actually lays out a geographic scenario, either city or world situation, and you can incentify the population that you're looking at and the size of the city that you're looking at. The market penetration of light duty vehicles that are hydrogen vehicles in that city to estimate demand, and the location of a central plant and hit a button, pick a pathway, I'm sorry, pick one either gaseous or liquid pathway or a variance of those two hit a button and the model tells you what the cost of the full infrastructure would be. Here's a case of that. Here's a case where they have a plant 100 kilometers outside the city gate. And a couple of things to notice about this. First everybody looks up here, you know kind of just draws your attention to that area, but what it says is so that what we knew before we did the model, at low market penetrations when you're only moving small amounts of hydrogen it costs a lot to move hydrogen. (Inaudible) that is why distributed production is so important.

The other interesting thing it levels out pretty soon. Not much after 20%. Certainly after 30% the curve is pretty flat. This is for current technology. So the team of people that put this together working with industry and we had a lot of help from industry on this, this is with currently available technology so the pipeline pathway has the lowest cost but it's still around $2 kilogram with the target being $1 and anything besides pipeline scenario is higher in cost.

Where do those costs come from? Well that's shown over here taking the same scenario and we break it down by components, and you can see that the refueling operation itself, compression storage and dispensing, is a major part of the cost. All these other components, each one is not that large. But there's many components and they simply add up.

Other accomplishments. The delivery tech team of the freedom car partnership has put together a really comprehensive and robust road map for hydrogen delivery, and that is now available on our website, and I would encourage people who want to learn more about delivery to look at that road map.

We did run a significant solicitation and we do have a robust portfolio of projects, although there were a few gaps that we want to fill, but unfortunately with the current funding situation, many of those projects are sitting there on idle waiting for next year's appropriation.

Within that, we've established a collaboration of collaborations, so to speak. We've put a pipeline working group together, you know, pipeline delivery of hydrogen just looks from all the analysis everyone has done as the way to go long-term at least for hydrogen transport or transmission. And there's a lot of issues that we need to face. You saw those costs. But we don't know enough about hydrogen and fuel pipelines to begin with to really be ready to build a massive pipeline infrastructure and other issues and you have to reduce those costs by 50%.

So the pipeline working group, like I said, is really a conglomerate of all of our pipeline efforts and they meet and share their results and work together across those budgets to get the full job done. We've got work on fundamental work on hydrogen imbridement and (inaudible) collaboration across national labs and industry. Within this we have a break through approach using composite price, it using in natural gas industry and well headers, we've had a couple of mini workshops we're working closely with the standards community which is very important when we talk about pipelines. And European commission has a large project on pipelines looking at the use of natural gas pipeline infrastructure to try to co-transport hydrogen and natural gas. The DOE is a member of that project's advisory committee and they really are part of our overall pipeline working group and showing in the meetings we have and the sharing of information.

We have additional analysis projects. The next collaboration which includes several partners will sort of take the next steps in terms of H2A delivery analysis and delivery analysis in general and build in carriers and look at some of the other delivery pathways that the current model doesn't look at. And as I've said we really need to focus on the collaboration we're doing separate analysis on that. We have learned some things, and I think we've identified what our key challenges are. Of course, as I've said fore court costs are a big part of the picture and basically comes down to compression and storage. We need more reliable compressors as well as reducing the capital costs of a single compressor.

Storage area, we've got to dramatically reduce the capital costs on those systems. That could be through the use of carriers, it could be through alternate methods. Believe it or not operating and maintenance costs i.e. the person who takes the money, and a few other O and M costs are also significant. Which sort of drives one to think about larger fueling stations and in fact if you look at today's gasoline infrastructure, you see that we're really going for larger fueling stations for the same reason. Pipeline looks like low cost known approach, so to speak. How can we get that being utilized sooner rather than later. How could we get, for example, a transmission line along the West Coast and a transmission line along the East Coast and move to central production and the economy of scale production sooner rather than later? We often need to solve the imbridlement problem before we move out and build major infrastructures.

Another question in this area is although we currently analyze using pipelines in urban areas for distribution, it's not clear that that's really going to happen. We'd like those pipelines not only to run with hydrogen but to run at much higher pressures than the natural gas infrastructure runs on and we want to put that infrastructure into cities that are already extremely build up where right-of-way item might be far too costly or completely unavailable. We're also thinking about the fact that we might be need a back-up for distribution. That might be a high capacity gaseous 2 trailer that holds, instead of today's capability of only about 2400 kilograms, holds a thousand or even 2,000 kilograms.

And then finally transition. As I said, low volumes means higher delivery cost, and we need a breakthrough if we're going to pull things in earlier or anything. And that's it.
(Applause)

>> Thank you, Mark. We'd like to invite your questions and comments now. In addition to our speakers, we have Peter Devlin on the panel from the EE Hydrogen Production Team, and as I mentioned earlier Tim Fitzsimmons from the Office of Science. In addition to the work you saw presented, there's basic research going on within the Office of Science on hydrogen production as well as other hydrogen technologies. Questions, comments.

Could you come up to the mic, please. And identify yourself and your affiliation.

<QUESTION>: (Inaudible) Oak Ridge National Labs. I have a question primarily for Carl. Considering the energy losses in converting electrical power to hydrogen by electrolosis and reconversion to electrical power in fuel cells, is there an analysis of the efficiency of electrolytic hydrogen production versus battery powered automobiles?
>> The analysis that has been done is looking at both the efficiency of the solid oxide electrolysis cells that are being developed, as well as the higher efficiency from the advanced nuclear reactor systems that are being developed. So the goal there is to look at something at a range of 40 to 60% for the combined system. But we won't have an exact read on that until we have both systems operating together.

<QUESTION>: Do you mean 40 to 50% from, as in the car, using it in the car?

>> Car --

<QUESTION>: There's another 50% lost in the vehicle, right?
>> Right. We haven't gone into that, no.
>> During our analysis session you will see the results of well to wheels analysis that looked at all of the hydrogen pathways. Any other questions? Yes.

<QUESTION>: (Inaudible) my question is on the coal program. Do your projects consider the (inaudible) assessment or capture in any way form or shape?
>> In the presentation -- is this on? I mentioned that there are a number of associated technologies, and to answer your question directly yes we have a major program looking at the capture of mercury from coal as an objective.
>> Yes. Question? Yes, please.

<QUESTION>: (Inaudible) Renewable Fuel Cells Association. I listened this morning about coal, natural gas, nuclear, wind solar, I never heard the word ethanol mentioned. And I listened to delivery and how tough it was to deliver hydrogen and infrastructure and the thousand (inaudible) with ethanol, using ethanol every day in the United States. It's delivered to the gas stations. It's a renewable fuel, and yet there's almost -- and the USDA, which is a program of the USDA and DOE working together, it's basically ignored. And we'd like to see ethanol get -- I'd like the DOE to -- construct a comment to consider ethanol in the structure. It's a reformable fuel, and I think we're getting very little play in all this, and it's certainly not up on the screens.
>> Well, thank you for that comment/question.

<QUESTION>: You're welcome.
>> We actually have a long history of working with ethanol. We talked earlier about our on board reforming technologies in which we actually focused quite heavily on ethanol from my own presentation I mentioned renewable liquids as a focus of our own program, and I'm sorry if I didn't enunciate ethanol as one of those renewable liquids. But it's certainly one. It certainly is an area that we have interest and focus on, although I think you also see that within the constraints of the budget I outlined. We don't have the resources right now to do as much as we'd like to with ethanol.
>> Let me add to that. We just finished reviewing eight projects that were primarily for reforming of natural gas. And the reason we did that was to verify the research results of this interim step, the $3 per gasoline gallon equivalent. Our next focus is going to be using ethanol with the same kinds of systems.

Now that we've got the costs down of these distributed systems. So it's coming.

<QUESTION>: When?

>> Soon.

<QUESTION>: Yeah, right.
>> We actually have three or four projects now that within the scope include work on ethanol and other renewable liquid fuels. Again it's a funding source that's preventing us from putting more efforts on it. But we already have projects in the portfolio developing systems for ethanol and other liquid biomass stage fuel.

<QUESTION>: Thank you, I think.
>> Yes.

<QUESTION>: My name is Peter Piper. I'm from Missouri. I would be interested in fact in the similar topic as was just addressed, mainly the on board reforming efforts, not necessarily in terms of ethanol, but including things like natural gas and whatnot, versus all the effort we've been hearing in the first session about, you know, on board to hydrogen storage and all these. My question really is: To what extent is the hydrogen program falls together interested in, for example, looking at source technology for on board storage technology for an on board storage of natural gas and then maybe the microwave reform, on board reform offering alternative routes to the grand challenge program.
>> Pat, do you want to handle that?
>> Yeah, I can answer that as a former fuel cell team leader. You know, DOE supported the development of on board reforming technologies for over a decade. We had a go/no go decision in 2004 that looked at those technologies, and evaluated them in an independent panel against set prices of our targets, and frankly by the way that independent analysis was not just an analysis of where the technology is today or was at that time, but where we thought it could be. And where we thought the limits of it were. And the results of that analysis was that we did not the independent panel did not believe that on board reforming could meet our targets. And specifically where they fell short were one start-up time, because these start-up times of these systems are pretty long and had to be under 30 seconds, and then almost as importantly or more importantly was the energy they consumed during start-up, even if you could start up quickly, how much energy did you consume and what was the impact on mileage. And so those two critical areas, and by the way some others that I'm not mentioning, on board reforming technology fell short.

<QUESTION>: Thank you.
>> Okay, two more quick questions, please.

<QUESTION>: Michael Shu (inaudible) Corporation. I have a question on the nuclear based hydrogen. For instance, the temperature range in target for high temperature, the electrolysis and also what candidate are actually will be used for the heat source for the high temperature electrolysis is the high temperature coal reactor coming back?

>> The second question first. The high temperature coal reactor is still one of the candidates for the type of reactors to be used. But the temperature range that we're looking at is from 750 up through 900 degrees for the process.
>> Last question.

<QUESTION>: Richard (inaudible) from GE. My question is also on nuclear-based hydrogen. All the technologies that Mr. Sink discussed were ones to take advantage of heat integration from the heat cycle, and I think that gives you 10 to 25% efficiency savings. My question is, since nuclear-based electricity so cheap why is that efficiency savings so important?
>> Could you restate the question, please.

<QUESTION>: Sure. Since all the technology seemed to focus on high efficiency conversion of nuclear power to hydrogen, the question is why is it such an importance on that since the cost of the electricity from nuclear power plants is so inexpensive.
>> The cost you might be discussing is plants today which are not at the temperature ranges we would need to use these high temperature processors that we're developing. So the overall costs of the energy system will include the cost of the new reactors, new advanced reactor that will be built as well.

<QUESTION>: I guess it's -- the follow-up is if you don't need to integrate the heat you can use today's reactors with their cheap electricity?
>> But the efficiency of the system together with the reactors today we would need more reactors to be built today to meet the needs for the hydrogen.

<QUESTION>: Thank you.
>> Any webcast questions? Okay. Well, with that, we're going to move on to our last session of the morning. We'd ask you to stay in the room and just maybe stretch while we switch over to the speakers.
We're running a little bit behind schedule. (Music)
Everyone be seated so we can get started.
We have three speakers remaining. The next three talks will cover programs within DOE that are related to the hydrogen fuel initiative as well as activities in Europe that are related.

Our first speaker is Sean Plasynski, who is going to talk about various carbon capture and sequestration programs within the Office of Fossil Energy.
>> I've been told if I don't to keep on schedule we'll have (inaudible) for lunch and that's it. I'll keep on schedule and go kind of quickly here.
Lowell set the stage for me to talk about the sequestration carbon capture being very important in using hydrogen. What I'm going to do today is try to give you an overview of what sequestration is.

Probably had a survey from people, this is the first time they've heard it, we'll show you what it is and what we're doing in the program to address this.

Now, I'm sure everyone has heard about global climate change and the increase of the temperature being linked to the increase of manmade C02. It's been increased significantly over the past 100, 200 years. And a lot of this is to the question of fossil fuels, namely coal.

Now, if we were to look at a particular scenario, a business as usual case, we'll see a tremendous, about 70% increase from the 2001 level. And if we were, just as a very simple case, to say, okay, let's get back to where we were in 2001, we have a gap between the business as usual and stabilization case in the U.S. in 2001 of over 5,300 million metric tons of C02 per year.

Now, there are several ways of addressing this. One, you can reduce the carbon intensity of the fuels. We've heard about renewables, nuclear, fuel switching.

Another alternative is to improve the efficiency and it's to be on the demand side that are sciences et cetera and also on the supply side increasing efficiency of power plants and other productions. And another third option is to sequester carbon. Capture and store it, enhance our natural sink.

All these options, you take them all into account to try to meet that delta that was shown in the previous gap. So we have affordable energy that addresses environmental concerns.

So what is carbon capture? Simply the separation and concentration of C02 from flu strings. Now there are three different ways of going about capturing it. One is on the post combustion, this is after the fact, after the utilization or combustion of the carbon fuel. You can do it on a precombustion such as in a gasification mode, prior to hydrogen production or other things and a third one is oxy firing, using an oxygen stream to replace the air stream so you have a pure stream of C02 at the back end a need for a lot of expensive equipment for capture.

The problem with this capture the three capture scenarios, they're very expensive. To try to implement them it can run anywhere from 40 to 180% of what the current cost of electricity is so the primary research goal in the program is cost reduction.

What is sequestration? Generally, we can look at it and see it in different ways. One geologic. There's the C02 to underground formations or it can state for hundreds of thousands of years and there's several various formations. May not be that clear, especially in the back.

But these conclude enhance oil recovery, enhance coal methane where we get value added product out of sequestering the C02. And into the reservoirs, the reservoirs which have a very high solid content and cannot be used for drinking water.

Another way of sequestration is terrestrial. This is enhancing or increasing the uptake of C02 by plants or enhancing the carbon storage within the soils.

Carbon storage. Basically it works by three different methods, four different methods. One is the actual physical trapping. We put it underground. We have the nice impermeable tap rock, the physical structure that's above it and all the subsurface layers on top of it. The second is the residual phase trapping, and this is the capillary forces within the formation. And an easy way to think about it is after you're done cleaning your clothes, washing them, take them out of the washer before they go into the dryer, they're still wet. Ring them out but they'll still be wet. There are forces of interlocking the water there in the clothes. The C02 can also be trapped that way. And the third mechanism is a more of a mineral trapping.

It binds up the C02 within the minerals that are within the reservoir. It has very slow kinetics, but with all of these over time it helps to improve the actual storage of C02, the natural analogs, the oil, the gas that's in there for thousands of years. We put the C02 back in its place. And a fourth mechanism is gas absorption, with enhanced coal bed methane. The C02 has a stronger affinity to the coal than the methane and thereby the methane will be released and the C02 will be absorbed there.

To give you some quick statistics on our program. It's in its tenth year, started back in '97 around a million dollars and has grown federally over the past ten years. It has very strong industry support. And this is something to highlight given that there is a regulation, no requirement for C02 capture.

We have a diverse research portfolio of about 70 R&D projects that are underway. And this pie chart, which has a breakdown of the program really has things split amongst different areas which I'll detail area, but we have a new piece of the pie that came in this year, which is substantial. It's congressionally directed projects.

We'll see what happens to the pie next year. Now, within this program we have a multitude of goals. First and foremost anything we do we want to make sure it's safe and environmentally acceptable. We have goals on the capture, separation and capture side they are very aggressive areas, ultimately by the year 2012 develop technologies that have less than a 10% increase on cost of energy. This is on an IGT plant on a TC plant double that at 20%, just because IGTC has some benefits to make it easier to capture, have a concentrated stream.

Now, just like in the previous presentations, it doesn't mean we have a technology we're going to go pull off-the-shelf and plug it in. Identify the technology, it's ready to move to demonstration and then deployment still ten years away. The other part is our sequestration or storage R&D goals. By 2012 we want to be able to predict storage capacity within a plus or minus 30% accuracy. Sounds like a wide range but when you're dealing with formations, several thousand feet below surface you want to be able to predict within a reasonable estimate just how much C02 can be in there.

The third major part of the program monitoring mitigation and verification. We want to be able to know just what happened to the C02 when it's on there. Have a complete material balance and C02 is in there. And as we go forward we want to be able to monitor and verify that can also mitigate any chances that there would be any potential releases.

This chart shows the structure of the carbon sequestration program. It really consists of two different areas, the core R&D which exists of capture. Sequestration, both geologic and terrestrial. Break through concepts. Non-CO2 greenhouse gas mitigation mainly methane and the monitoring and verification of mitigation. I talked about some of the goals in these previously.

Another major part of the program is the infrastructure. In this part of the program, we're attempting to lay the foundation for sequestration nationwide. With it, there are seven regional partnerships, and these partnerships are gauging the regions on state and local level, determining any benefits within a region. Baselining just where the sources of the C02 and the potential sinks are. Establishing what is needed for monitoring and verification protocols. Very key issue is the regulatory environmental and public outreach. We want the public to be comfortable, with what will occur with geologic sequestration and also to validate the sequestration technology. Both parts of the program help to see into a more integrated project. And this is future. I'm not going to spend any time on this since Joe will talk about that in the next talk.

But just an update on the regional partnerships. Completed phase one, which is the characterization phase. We have seven partnerships to cover 40 states. Phase two, which is a field validation started last October. It's a four-year phase. All seven partnerships continued into phase two. $100 million of federal funds and $45 million in cost share. And in phase three planning stage for deployment we're looking at about a eight year time frame looking at some very large cell congestion tests greater than a million tons per year.

Just some highlights in the first phase, the partnership identifies thousands of years of storage capacity. This includes coal schemes, oils and gas reservoirs, and the biggest potential, the formation with potential of over 5,000 giga tons. There's also been identified value added product in the potential sink.

30-R potential produced and favorable fields and coal teams of over 126 cubic feet of coal bed methane.

In addition, the partnerships are helping to feed data into what is called the National Carbon Sequestration Atlas for the U.S., also known as NATCARB. Available on line at natcarb.org. You can query the map you can see the sources of the sink and other potential transport issues.

This is a map of our regional partnerships. There are seven across the U.S. The little dots represent one of the field tests they'll be conducting. Generally 25 geologic tests throughout the U.S. and one in Canada. And everything from oil bearing, gas bearing, saline, coal scenes and shell and they'll be projecting anywhere from a thousand to over 500,000 tons of C02 over a several year period.

Here's just a quick example of one of the partnerships. This is a west part partnership out in California. They're doing a fax sequestration DOR saline aquifer test. At the end of this year they'll be putting approximately 2,000 tons of C02 in the saline reservoir and above that enhanced gas scenario, by the end of the following year another 2,000 tons. What's nice about this is we have physical trapping above the first one and also above the second one there's multiple layers to help keep any C02 that we sequester in this formation there.

Within 128 fields, the Sacramento Valley, there's over 1.8 gig of storage capacity that was identified, and it's estimated that 140 to 840 within just the saline formation in California is possible.

Some of our examples from our core R&D separation and capture. These are some advanced capture technologies. Ionic liquid. It's been discovered they're highly soluble. C02 is highly soluble in them. Stable. Nonvolatile. And an additional thing that we're finding is it can also capture C02. Can become a multi-capture liquid capturing XO2 with C02. Another potential is metal organic framework, and the previous speaker had talked about that. So I'm not going to go into that. We're looking at it from the point of capturing C02.

One thing I want to bring your attention to is a funding opportunity announcement that we currently have on the street. It's looking for novel technology and commercially focused approaches to C02 capture and separation.

It closes in June 16th. It comes in three different areas. There's approximately 39 million in DOE funding requiring 20% cost share on the project. And the west side is given below, and I believe the packets in the beginning had all this involved with the presentations.

Just a couple more examples of some of the accomplishments going on in the program. We have a saline reservoir called the Frio Brian Reservoir Pilot Test. Looking at the capacity and the Gulf Coast saline reservoir. Back in 2004 we had a first phase. We injected a 5100 feet 1500 tons of C02. We were able to validate many models with this. Come up with a lot of monitoring technology, and started developing the expertise we needed for large scale C02 injection. We're doing a follow-on phase, smaller in scale. It will probably be starting in June or July. And it will be, again, looking to further refine reservoir models we have and to develop the best practice for this type of sequestration. It's proved successful. The PI on this has gone out door to door to the various people in the community. There's been no opposition. The only questions have been because of the transport of C02 by tractor/trailer loads, how much long for the truck to come back and forth, really no concern of the subsurface.

We have one more project with MMV. This was at a Weyburn C02 field. I want to point out two quick things. The C02 is coming from a North Dakota gasification plant, travels within the pipeline with H2S and they're utilizing this to store C02 in the field but also to increase production of oil. And this curve right here helps to show the additional oil.

I'll pass it over and I will conclude and just recommend you to our website for additional information.
(Applause)

>> Our next speaker is Joe Giobi, who will talk about FutureGen.

>> Since we're over time, I'm going to go very rapidly. 14 minutes and 55 seconds, that's what we're coming in in. So we're not over because of me.

Thank you, JoAnn, and good morning to everyone. I'm Joe Giove. I'm the senior program manager at Office of Clean Coal and working on the clean coal project. I've been asked to give a presentation.

What do I need to do here? There we go. Give a presentation on what FutureGen is, what we're doing with the program and where we're at and where we're going.

Also because of some announcements and press releases that have happened within the last week, some of the things I'm going to say are in addition to what's on the slide. I'm also going to skip through a couple slides.

This is basically what I'm going to cover, give some background and give a look at the future U.S. outlook, what FutureGen is, why it's important. Look at the supporting research development program for FutureGen to schedule the progress we've made next steps in the project and then I'm going to summarize.

This is a chart that you've all seen in one form or another many times. The basic point here is that coal is going to be in the energy mix for the foreseeable future. We can argue about what the slope of the line is going to be. We can argue about what we want the slope of the line to be. But FutureGen is hoping to help the slope of the line be that we use coal and use it more cleanly and more efficiently. We can call it Saudi Arabia coal and in U.S. we have a 250 year supply of coal and we would like to use it.

Charts like this show with the electricity generation over the next several decades might look like. Now in the United States electricity market, we utilize a great amount of coal and a high percentage of our electricity comes from coal. Currently accounts for 54% of the U.S. electricity consumption.

And the U.S. energy information administration forecasts 49% growth of coal in 2025. This is assuming we have a 39% growth in all of the other areas. Natural gas, nuclear and renewable. 29% growth in these other areas we may even be utilizing more coal. I'm going to skip this slide. So this is a goal of the FutureGen research project to establish the technical feasibility economic viability and broad acceptance of co-producing electricity and hydrogen from coal with essentially a mission including carbon which we hope to eliminate through sequestration. There are three things we're focusing on here. One, the technical feasibility. Will the plant run. We'll have a mix of advanced technologies and traditional technologies. Is there going to be considerable down time once we integrate these technologies together. I seem to be having difficulty but bear with me.

When we take these technologies integrate them together will the plant run or will it have sufficient down time? And economic viability. Is the plant going to be profitable in tomorrow's marketplace? Will the utilities operate it? And of course the broad acceptance. We're going to have to have a comprehensive test plan and a scope that involves testing a variety of coals by (inaudible) lignite and storage and monitoring scheme and huge potential including saline reservoir and involvement of international partners, coal producing and companies for broad acceptance.

I'm skipping this slide.

Okay. FutureGen will be an international test facility for breakthrough technologies that address three key presidential initiatives: The Hydrogen Fuel Initiative, Clear Skies Initiative and the President's Climate Change Initiative.

The future initiative was announced by President Bush on February 27th, 2003. Here's some of the specific goals of our program: We desire to design, construct and operate a 275 megawatt prototype plant that produces electricity and hydrogen fuel while sequestering CO_2 (inaudible) over 1 to 2 metric tons a year. Why 275 megawatts? We chose this slide for several reasons. We're not interested in on a plant that will finally solve the issue, somebody is going to say you need to resolve it at a higher scale. They're looking at a full scale plant, 275 megawatts.

Secondly, a 275 megawatt plant at 50% availability will produce one million metric tons of C02. At 100% it will produce two million. We believe that's the amount of C02 we need to adequately stress and strain the underground geology to see if the sequestration concept is safe, because as Sean just said, if it's not safe -- then don't turn the lights on me. There you go. If it's not a safe concept, then it's not a viable concept and it's not something that we want to have replicated and have broadly accepted.

Also one million metric tons is comparable to (inaudible) and Weyburn. We desire to sequester 90% of the C02 and eventually 100%. We want to prove the effectiveness of C02 sequestration, validating the concept it's the key at large scale and the real world conditions. In doing so, we hope to establish technology standards and protocols for C02 measuring monitoring and verification and to validate the concept by 2020. These are a very aggressive schedule, because if we can prove this concept by 2020, perhaps it will be an option that we can look at to replace some of the aging coal plants in the U.S. and even an option for some of the new ones.

We believe that FutureGen is not just a step but a key step in creating a zero emission energy option. Zero emission coal will enable countries to meet their growing energy needs and secure an economic and energy future for clean of coal and strategic energy resources especially in the United States. Here's a few points. All environmental concerns of this whole use including climate change concerns, sequestering C02, producing clean low cost hydrogen with zero emissions for power generation or transportation. And the final bullet down there: Integration and scale up of these coming technologies is going to be one of the key factors as to whether we're successful or not.

These are some of the systems that you might find in a zero emission system like FutureGen. And this system, coal is burned in the presence of zero oxygen, large gasifier. The stream which contains carbon monoxide and pollutants, sulfur and mercury and others. A number of gas cleanup stages and you're going to do your shift. And then we're going to have to separate the hydrogen and the C02. This is obviously simplified. Hydrogen would be used for power generation either through hydrogen (inaudible) or (inaudible) fuel cell or for production of hydrogen for chemical. C02 will be sequestered in the generation in the amount of saline or deep coal reservoir and enhanced opportunity for oil recovery.

We also, Office of Fossil Energy, we have aggressive research development and demonstration program, support and development of technologies we hope will be ready in time for incorporation of the FutureGen. On the left part of the slide you can see technologies that are considered standard off-the-shelf technologies. Many of them demonstrated and are fairly reliable. On the right side there are advanced technologies that are being developed and could be considered for FutureGen.

Some of them might be ready in time and some might not. It's the role of the FutureGen alliance that I talked about shortly that will determine what technologies will go into the FutureGen plant. We on the government side put the mission we need the capability of zero emission plant, and provided much of the funding. It's the alliance which are the users of the technology and eventually the replicators of technology that need to get comfortable with what technology they're going to incorporate together to meet that mission. This is a very simple project schedule. The supported research and development that you can see is ongoing. The construction is ongoing to design and construct. You'll see the research will continue to support the design decisions. Some decisions can be deferred as part of testing that will correlate in operations. We expect it to begin around 2009 time frame and 2011 and 2012 and follow-up post monitoring of storage of C02.

You don't like that slide? That's fine. I don't like it either. Here we go. The slide you're not seeing right now is a slide that talks about the FutureGen alliance. In order to accomplish our mission, the U.S. government has signed a cooperative agreement with a nonprofit organization called the Future Gen Alliance Incorporated to design, construct and operate the plant. The alliance consists of nine organizations representing 15% of U.S. coal fired utility and 40% of U.S. coal production plus a coal-based utility in China. The China (inaudible). The alliance is an open consortium both domestically and internationally and is geographically diverse and includes producers of coal (inaudible). The alliance are American Fire and (inaudible) Kennecott (inaudible). This slide is, shows the government steering committee. In addition our industrial partners we have invited international governments to join with the United States government partnering on the FutureGen project and these governments will get a seat on the steering committee. On April 3rd are India became the first member of the FutureGen governance committee and south Korea responded positively they will join and negotiations with other countries are promising and ongoing.

Participating countries have also had the opportunity to provide technical advice by sitting on technical subcommittees and you can see those listed in the blue box in the interests of time I will not read those.

What progress have we made today? The agreement was signed in 2005 with the FutureGen lines to initiate the first phase of the project. They had site selection in 2006 and responses due May 4th, 2006. I can now update you on a press release that was on May 9th. The alliance announced that 12 sites in seven states had submitted proposals to help the FutureGen site.

The site locations and these are in alphabetical order by city and by state are (inaudible) Illinois, Marshal Illinois (inaudible) Illinois (inaudible) Illinois. Henderson County Kentucky. (Inaudible) North Dakota (inaudible) Ohio. (Inaudible) Ohio. (Inaudible) Texas. West Virginia and Gillette, Wyoming. The DOE has issued advanced notice of intent for Environmental Impact Statement on 2006. The other projects are identifying the cutting edge technology and readiness for inclusion for future evaluation by the alliance. We've done some conceptual designs on several configurations and we've priced those out and those have been completed we initiated the planning process for the permitting process and we developed our NEPA strategy and (inaudible) including plans for the public scoping which is part of that process.

Next step in FutureGen we're going to start the evaluation process now that the announcement has come of what the 12 sites are. We're going to be based the plant configuration and starting the preliminary design. We'll be assessing the cutting edge technology to see which ones might get into FutureGen. We're going to be developing the test scope for validating FutureGen, conducting the (inaudible) activities for the permitting process and I'm aware some of this has been done out in DTO. We'll construct the formal NEPA process it starts with the notice of intent that will come shortly beginning work on environmental information data gathering, developing things for public scoping we'll be establishing the government steering committee now that we have three countries in the near future. And we're going to be continuing outreach to bring additional participants in both participants on the industrial side and participants on the governance side.

So my final summary remarks, we believe FutureGen is a key research step for putting the feasibility of coal option. The plan is on track in terms of our progress and funding for our initial phase which we have. Evaluation for proposed sites is underway to find the best qualified sites. We expect site selection by the alliance upon completion of the NEPA process.

The cooperation support of many international take holders is going to be needed in order for this project to be successful and accepted and

the potential benefit for the emission coal option are enormous with respect to energy and environmental and economic viability. There's some websites. They're on the disk you can look at that will be helpful. Sorry about the thing with the slides. But I will be available since we have discussion I'll be available for anyone who has questions during the break. Thanks for your time.
(Applause)

>> Thanks. Last but not least Phil Borthwick of the European commission will talk about hydrogen activities in Europe.
>> Thank you. Let's hope I can walk through this. First of all, let me thank you and particularly to the DOE for this opportunity to speak to you today and to give you an update on the European hydrogen fuel cell and the demonstration of (inaudible)

I think time is very short so I'll have to omit some of the detail on these slides and go at a fast pace. I'm Bill Borthwick working at the Directorate General for the European Commission for Research in the unit energy production system which is (inaudible) so I think presented to you before last year.

Before I go on I'd like to acknowledge the contributions of my presentation from my coworkers and also from the colleagues in (inaudible) listed there.

Well, I think I'll skip the history lesson. Suffice it to say European union comprises 25 member states that were 15 up until two years ago then we added a further ten and we're in negotiations at the moment for a further four countries listed there.

And we have 450 million people GDP something approaching $10 trillion within the United States. And all have a great deal of economic potential there.

I'm going to speak a little bit about the policy context. Some of the framework program. We worked in multi-annual framework programs normally running four years. I'll talk a little bit about the strategies that we're developing for the framework program certain and some of the plans for the framework program certain and in particular the new joint technology initiative.

The policy context I think it's similar to what we have seen in the presentations already to date. And the European union, three main pillars of policy guiding the energy research and which drive the hydrogen fuel program. GOP energy supply production of greenhouse gasses and we're committed long-term on combating time change and also improving industrial competitiveness and recently we published a green paper called the European strategy. First competitors and secure energy and that's open for consultation at the moment and that's looking at balancing these three pillars which are sometimes comparative.

I think I'll skip this one, the main message here is C02 emissions will increase slightly over the next 30 years. The mean area is we increase transport in power generation and these are the areas of research can bear fruit.

Scenarios for fuel, for motor fuel I think similar to what we've seen this morning. The Americans bio fuel pattern already now and going to 17% by 2020. And (inaudible) natural gas and hydrogen fitting in from (inaudible) all some 23% constitution (inaudible) by 2020. A brief view of the fixed framework program. Basically the research naturally supports the policy pillars. They're short medium and medium long-term developments for conventional hybridization vehicles. Using oil (inaudible) vehicles, natural gas. Research for clean fuel production.

We have a challenge, of course, as you've seen the 25 member states many have the research programs and we need to align these to get the most efficient use of the resource.

We've got R&D focusing on the material and downstream actions on technology validation and demonstration.

This is a change in the budget for the framework program. The framework program starting from the mid '80s you can see it's doubling more or less each framework from framework program three. Presently the European commission support (inaudible) research to the extent that 288 million Euros corresponding to our own 600 million total. It's worth pointing out that in addition some of the bigger member states have bigger higher hydrogen program and (inaudible) 500 million program over ten years I think it is.

This is how this budget is allocated. You can see the main area the spend in the technology validation and demonstration, hydrogen production and fuel cell transport. You have to see there's some caution you have to take in testing these because in demonstration there are all kinds of safety hydrogen production and infrastructure.

In membranes, we're working on development of membranes and near technology. These are based on commercially available (inaudible) (inaudible) we're going towards the high tension membranes based on (inaudible) polymers. PBI hybrid and inorganic and organic membranes and these are being developed along with the (inaudible) and small batches and these are some of the EU projects in that area. We're moving towards high temperature membrane now, looking at raising operational range from (inaudible) 130 centigrade with chemical and mechanical robust and (inaudible) and these are the two areas where we're concentrating on with there.

We have an effort on coordination of these we're negotiating a network called charisma. We also have an extensive program in SOFC program. SOFC and 600 looking at Harmonization and standardization and in the case of the 600 temperature down (inaudible) range and this is supported by work in these cells back in system testing in the FC test and FCTest QE. We have a number of hydrogen production on conventional roots. Work on (inaudible) and hydrogen production from natural gas. We've got developed -- we're developing technologies to reduce the cost of carbon dioxide capture. To that target mentioned there and we've got (inaudible) production either small scale fuel flexible systems.

Concentrating on these items. We're also doing work in alternative routes for hydrogen production. There's a project even with hydrogen production from solar thermal energy forming solar reactors doing coal production of hydrogen carbon black. (Inaudible) system. In terms of chemical -- and we're exploring reaction with (inaudible) and being watched on a (inaudible) full of oxide and (inaudible) we also have some efforts on upstream research linking molecular genetic and bio (inaudible) and also looking on decentralized production from biomass and the two stage process listed there.

Work on storage covers both complete liquid and solid and the project stored on 700 bar, therefore (inaudible) looking at production processes and new permeation barriers. Working on the seven technology, the (inaudible) systems and the valves.

I think one back. So with the storage systems we're doing work on cryogenic manufacturing membrane and looking in particular to production potential. We've got some extensive work ongoing on looking at the issue of safety and regulation of program standards. Specifically for fixed fuel infrastructure. You can imagine 25 member states there's many different views on how you should position or locate your filling stations. Also for stationary system, we're working extensively in the area of hydrogen safety through the network high space. That's looking at (inaudible) database, benchmarking CFD codes. Safety training and we're looking also at hydrogen releases in these confined spaces. Safety of storage is also being investigated also we have a program to look at the requirements of (inaudible) of research in the future based on the harmonized project, mandate from the same standards body and also looking at standardizing testing protocols.

Extensive program of technology validation and demonstration and this in the next year you'll see some 200 vehicles that have demonstrated (inaudible) extension of the well known (inaudible) bus project that includes combustion engines demonstrating our own cars in the (inaudible) project in Germany and Italy and quite a large number of small mini transport applications which you can see there.

And that's all pertains to the context of an assessment framework on the program. Seventh framework program, we call it building a Europe of Knowledge, and anticipating the present framework program there's a number of what we call technology platforms to develop the vision and strategy to help one specifically in hydrogen, and they're produced some key documents for research agenda and deployment strategy. And there you can find all the targets and time lines that we envision as necessary for developing the hydrogen system.

There's also technology platforms in the area of the emission power generation looking at carbon dioxide sequestration capture of the chryo fuel. Not looking only at research requirements but the long term vision of human capital requirement, the issues of public accessibility. These are some of the projects in the fund strategy. I don't have time to go into these. This is the anticipation for the framework program seven. We want to know the budget. At the moment it's not known because it's a subject of a discussion between the European parliament and the counsel of ministers. There's a budget on the table of over 40 billion Euro and it's compared as to what we had in (inaudible) only part of that of course will be on collaborative (inaudible) and only a smart part of it will be on hydrogen fuel cells that we don't know much yet. This is the base of the main topics that will be covered in the energy part of the program. We'll have explicit actions in hydrogen carbon capture and renewable fuel all of which will lead to hydrogen. (Inaudible) for FP7 will be in the process of the core decision right now the parliament reading those as well the adoption of those at the end of the year (inaudible).

New development in the FP7 is what we call the joint technology initiative. And this is really a radical departure from the way we've done business in the past. New management structure a more efficient organization FP and demonstration this will be in the areas of major energy interest. Energy is a key area now. This is in the areas of (inaudible) significant critical mass to achieve the desired objective. So the (inaudible) to implement the program the strategic research agenda the deployment strategy initiative it's a public private partnership, strong industrial participation. Facilities and realignments of the research activities in the member states and developing outreach at the international level.

These are some key documents that have led to the development of the JTI, the initial high level group vision report looking to long-term strategy with hydrogen produced from ever increasing amounts of renewable energy. Then there's the platform document that I've mentioned already and know the challenge to JTI is to translate each strategy into what we call implement al action. These are the main topic areas in that field. So a fuel cell development program, program on sustainable hydrogen supply, lighthouse -- sufficient lighthouse demonstration programs with a phase approach and (inaudible) improvements in technology demonstration. And then market framework for power activities, these are all the cost cutting activities that are necessary to bring these technologies to the market.

And in the hydrogen fuel cell technology platform that I mentioned before, currently we have what is called an implementation panel and that is working very hard to come forward with these concepts of implementable action. We hope to publish in June what we call implementation and implementation plan and at the same time we're exporting options for the governments of the JTI. So concluding then some key issues as we see it in the European union. We do see the future perspective is a mix of transport fuels, conventional fossil fuels and bio fuels and blends of these of conventional fuels, natural gas and of course hydrogen. And we have to be conscious of the role each of these play. The actual (inaudible) hydro fuels are difficult to predict. As mentioned we have 25 member states that have different capacities and different circumstances, and it's a complex business to develop a strategy from that. And this concept between the use of also the bio mass. And in going forward in developing our strategy for hydrogen, Europe like the U.S. is addicted on oil and so transport is something like 99% dependent and by 2030 we'll be 90% dependent on imported oil as not the oil (inaudible) we already know. But we need these transition pathways to get to the hydrogen economy if you like which did not increase the energy in the environmental burden that demonstrated that can lead to reduction. And we need the strategy in terms of fuel. They need to be analyzed more comprehensively, often for infrastructure buildup analysis to see how this can be produced in a viable and bankable way.

And finally a key issue for transition is the option of centralized versus localized hydrogen production. The placement of the vehicle suite is the biggest cost hurdle not the actual infrastructure investment. We see that the OEMs and energy companies looking at how to realize the commercially viable strategy avoiding standard investment at the same time we see the OEMs recognize the top benefits of hydrogen fuel cell. Hydrogen storage, of course, on board a big barrier. We need more than that transition strategy analysis and I think the message that I do want to end on is that there's a lot of challenges there and I think that we see that this would be hugely beneficial if we can work increasingly together to overcome these, and that is basically why the European union is strongly supporting the efforts in the international partnership for the hydrogen economy, and that is a message that I want to leave with you.

Some final addresses to obtain some of these key documents. This will be up loaded on the web. So I guess that you'll get that information from there.

And, finally, this is our vision for the hydrogen economy coming out of the high level group. Thank you.
(Applause)

>> Thank you. Just one more minute and we can go off to lunch. I want to thank all of today's speakers. Couple speakers at the end here actually shortened their talk to go to lunch sooner. I appreciate that. This plenary was meant to give you a snapshot. The details will be presented in three parallel technical sessions and the poster sessions that follow. And many of you in this room are going to be, have volunteered your time to evaluate the projects that are going to be presented the rest of the week, and we want you to know that we really appreciate that. We thank you tremendously for doing that.

And finally I want to acknowledge the diligence and hard work of the people behind the scenes who are making this meeting happen. They've worked a long time and they've continued to work here and if you're in the room, please stand up. Judy Abraham. Rich (inaudible) Melissa Lott and George (inaudible) contractors helping us to put this program on, and --

(Applause)

And they're probably running around somewhere making sure that we have lunch. Dale gardener, our system integrator from the National Renewable Energy Lab. Dale are you in the room? And from our own program Carol Reid and Antonio Louise, standing up here. Stand up guys. They really made this happen.

(Applause)

So have fun. And we welcome all of your comments, any of your comments, not just the reviewers, just stop us in the hallways or send us an e-mail and thank you.