Systems Analysis
Summary of Annual Merit Review Systems Analysis Subprogram

Summary of Reviewer Comments on Systems Analysis Subprogram:

The reviewers considered the Systems Analysis Subprogram essential component to the Hydrogen Program mission and critical to the President's Hydrogen Fuel Initiative. The projects are considered appropriately diverse and focused on addressing technical barriers and meeting targets.

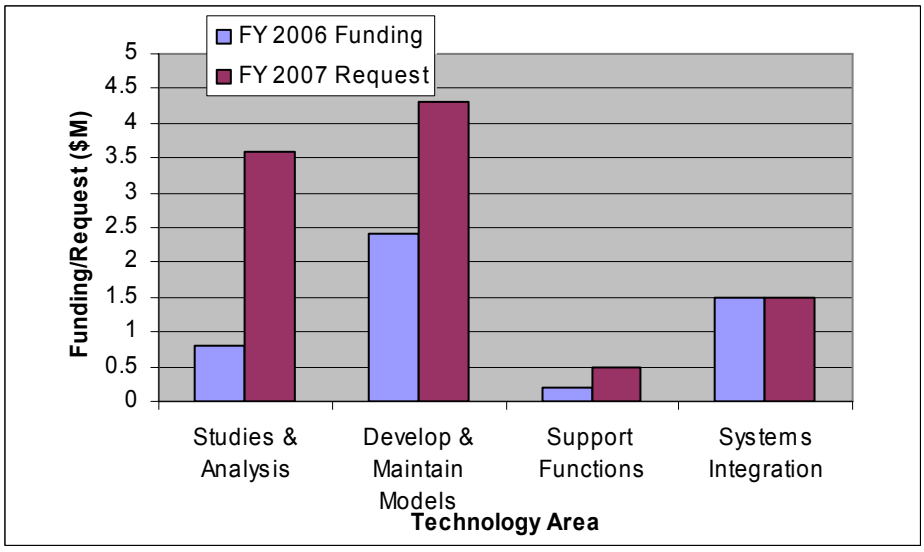
In general, the reviewers noted that Systems Analysis is a complex subprogram but is receiving the appropriate management attention. Some reviewers commented that the subprogram is well managed and has adopted an organized approach for analytical support of the Hydrogen Program, which is consistent with addressing the comprehensive list of identified barriers.

The major concerns identified by the reviewers for Systems Analysis were: 1) coordination and cooperation with the other DOE offices, e.g., Biomass, Solar and Wind, is required; 2) the plan for how the analytical parts fit together should be defined; 3) roles of the various models should be described; and 4) a summary of the common set of inputs and assumptions used for the modeling should be provided. The Systems Analysis subprogram addresses these issues in the Systems Analysis Plan which is soon to be issued.

Finally, the reviewers commented on the need to understand the international drivers and factors impacting a hydrogen economy. The models and systems should evolve to include the analysis of the impact of the world economy on the U.S. fuel systems.

Systems Analysis Funding:

The funding portfolio for Systems Analysis primarily addresses the model development and required analysis to support the Technology Readiness Goal. The requested 2007 funding profile, subject to Congressional appropriation, addresses the National Academies' Report recommendations and provides greater emphasis on the transition analysis.



Majority of Reviewer Comments and Recommendations:

In general, the maximum, minimum and average scores of the reviewers of the Systems Analysis projects were 3.7, 2.7 and 3.1, respectively. The Systems Analysis project portfolio includes a mix to address the "analysis and modeling gaps" of the subprogram and the transition requirements. The major recommendations for the Systems Analysis projects are summarized below. DOE will act on the reviewer recommendations for the overall Systems Analysis effort.

- **Hydrogen Production Infrastructure Options Analysis Project:** Consider adding actual supply and demand data from gasoline station performance to answer questions of committing overcapacity/supply without policy incentives. Emphasis should be directed to analyzing the advantages/disadvantages of different pathways that minimize capital risk early in the transition.

- **Impact of Hydrogen Production on U.S. Energy Markets Project:** Focus on the linkage and integration with other models to insure consistent inputs, outputs and assumptions are being utilized. Introduce plug-in hybrid technology in the analysis of alternative pathways for energy security.

- **Analysis of the Hydrogen Production and Delivery Infrastructure as a Complex Adaptive Model Project:** Considering the complexity of the modeling approach, incorporate a broader advisory group to enhance the model applicability and adaptability with other models. Ensure the agents representing industry include risk profiles, spending practices and business goals. Introduce methodology to analyze policy implications.

- **WinDS-H_2 Model and Analysis Project:** Ensure this model is incorporated in the Macro-System model architecture. Focus on adding demand forecast information and model output in the model as a next step. Consider the addition of gasoline hybrid and plug-in hybrid technology in the modeling structure.

- **Macro-System Model Project:** Ensure common and consistent assumptions and inputs are utilized in the linked models. Emphasis on a coherent summary report product from the model is required.

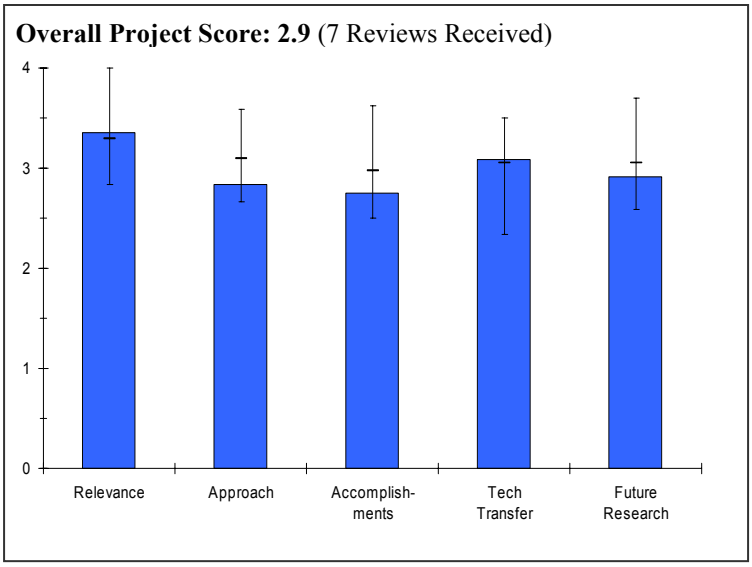
- **Hydrogen Transition Modeling and Analysis:** HyTrans v.1.2: Ensure the model analytical capabilities include plug-in hybrid and other alternate fuel vehicles.

- **Hydrogen Analysis Resource Center (HyARC) Project:** Focus on continued maintenance and updates to the resource center. Introduce international data and information as a resource. Consider adding safety and education information/data to the resource center.

Project # AN-01: Hydrogen Production Infrastructure Options Analysis

Brian D. James; Directed Techs.

Brief Summary of Project



The objectives of this project are to: 1) Create an analytical tool robust enough to assess the impact of different assumptions on hydrogen infrastructure development; 2) Exercise the tool using various assumptions to understand the infrastructure's sensitivity to different scenarios; and 3) Suggest to DOE areas of further research based on the most influential parameters in the infrastructure development. The unique features of this model include: its ability to evaluate infrastructures with varying utilization over lifetime; its ease of use; an interface aimed for use by a wide audience; a structure that can be incorporated into the Macro Model; the allowance for investor demand foresight; incorporation of stranded asset logic; user input of yearly varying hydrogen demand, unit efficiencies, and capital costs.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.4** for its relevance to DOE objectives.

- Analysis of the infrastructure options is important to planning the H_2 transition
- Should be a good tool for examining affects of various parameters in making choices between various approaches: thus could be useful in making Go/No-Go decisions regarding options.
- The model will be useful for evaluation of H_2 supply options, with the proper input data.
- Project relevant since infrastructure development is essential to reach goals and objectives.
- The optimization of the development of infrastructure is a key issue for the overall program.
- It is important to understand H_2 transition costs and the impact on technology options.

Question 2: Approach to performing the research and development

This project was rated **2.8** on its approach.

- Objective function approach is sound. Assumption of a fixed demand growth rate is simplistic. Assumption of homogeneous demand per geographic area is very simplistic; other investigators have considered regional-specific demands for some time. The cost-based decision of technology for build-out is a good approach. Matlab is appropriate tool, reading Excel sheets is convenient to H2A users
- The production modeling appears robust. It is not clear that one can isolate it from the distribution side to developing cost/ infrastructure development models. Future value would be improved if the effort was better connected to distribution versus making generic assumptions.
- Stranded asset logic is a strong point. Objective function cost approach is a good one. Fairly complete inclusion of various production options. Basic premises of model are straightforward. While it allows different scenarios and lots of parametric variations on inputs, it doesn't clearly state how these inputs will be defined: user must be careful to avoid "Garbage In-Garbage Out" syndrome. Not clear how they are treating "externalities", such as policy and technology issues
- The model's purpose is to evaluate between hydrogen supply options, which it can do. Some additions, such as including variability in demand, would improve the model.
- Consider using much higher overcapacity scenarios. Not sure if using H2A Delivery Scenario Model is going to give the right delivery distance/cost.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **2.8** based on accomplishments.

- Good partnerships established in advisory board. These 1st year results are obviously in hind-sight; local SMR is known to be the most cost-effective. The revised result showing coal gasification contributes at higher demand indicates that the approach can be used to select production technologies; however, for the build-out to include more than one technology option, regional-specific demand must be used in the future. It appears that the progress this year was primarily in building the model.
- The analysis is not at a point that there is confidence in the results such that forward planning can occur.
- They appear to be moving along fairly well. Might be premature selection of SMR forecourt option, since one might expect significant rise in natural gas costs in near future Demand curve may well be dominant, and it is not at all clear how good the one being used is.
- The presentation could have focused more on the assumptions and input data, instead of narrowing in on a conclusion at this stage. Conclusions are premature until the input information is validated. It is important to understand the sensitivity of the variables and how intangible considerations are handled.
- The model simulates an optimal infrastructure build.
- Concerned that Forecourt Production is always the best case given the close involvement of H2Gen.

Question 4: Technology transfer/collaborations with industry, universities and other laboratories

This project was rated **3.1** for technology transfer and collaboration.

- A strong set of collaborative partners.
- Appear to have participation of meaningful groups, namely representation of the oil industry and of commercial gas producers.
- The project has several advisors from industry. Additional input on the business assumptions and to gather the most accurate input data would be helpful.
- Collaboration with industry is evident.
- Consider sharing model with other analysis teams, e.g. H_2 Delivery Analysis Team, and more collaboration with other technology developers.

Question 5: Approach to and relevance of proposed future research

This project was rated **2.9** for proposed future work.

- The future plans should include removing the assumption of homogeneous demand to consider some kind of regional distribution.
- The proposed next steps are appropriate and are on target.
- Task 4 among the listed future tasks is probably the key one.
- As identified, looking at build out capital will be a good next step. An additional consideration would be to analyze the advantages/disadvantages of different approaches that minimize capital risk (and encourage investment) early in the transition. It does not appear as if enough effort will be made to improve data input quality. Without that, the model will not be effective.
- Sensitivity analysis proposed is important in order to test the robustness of conclusions to variations in costs.
- Consider looking into additional demand and build-out scenarios that are regionally dependant.

Strengths and weaknesses

Strengths

- Modeling infrastructure choices with objective function is a good technique. Analyzing the infrastructure development with build-out charts is instructive.
- Objectives clear and well-defined Stranded asset logic inclusion is important Appears to include all likely production scenarios: no wasted effort on less likely approaches such as thermochemical production of hydrogen.

- The model appears to be flexible and consider a substantial number of variables, including an attempt to consider real world business conditions. As identified by the presenter, the challenge will be to assure accurate data to the analysis. The program manager is knowledgeable on the material and has adequate experience to complete the project successfully.
- Designed to interface with H2A and Macro System Model. Real world asset utilization levels & stranding of assets is represented. Inclusion of existing hydrogen supply provides realistic initial option.
- Very good use of existing H2A models.

Weaknesses

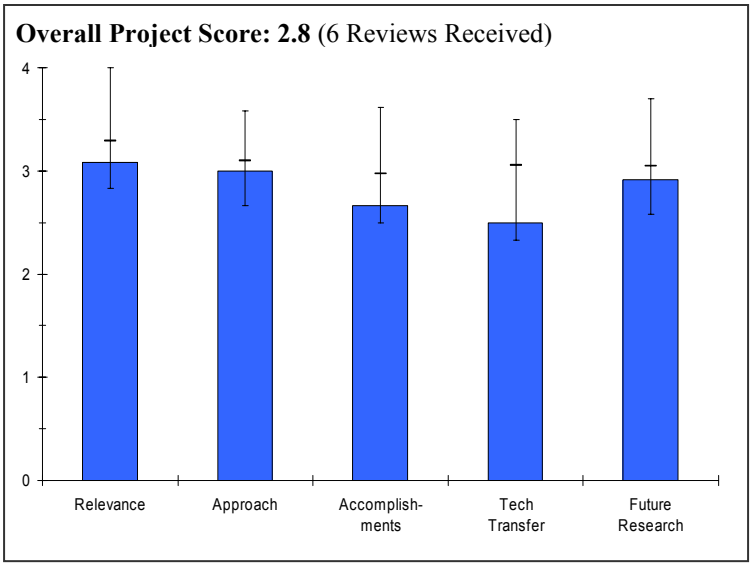
- Assumptions on demand oversimplify the problem and make the results less interesting, especially for homogeneous regional demand
- Objective Function Cost not well defined. Not clear how they are handling "externalities" Possible premature selection of forecourt Steam Methane Reformer given likely sharp increases in price of natural gas in near future. Strong dependence on Demand curve needs to be addressed/examined.
- The analysis does not take into account varying demand at stations during normal course of business. This might significantly affect results. It also appears to assume that a single station size and/or single station type would meet all needs.
- The demand assumption does not respond to infrastructure build. The basis for investment in the infrastructure does not appear to be market based - a central planning approach appears to be modeled. Overcapacity will drive investment decisions towards lower capital cost options. Other constraints such as GHG are not influencing outcomes. The feedstock cost to production facilities appears to be independent of location whereas it will vary in reality. Cost is determined offline – what does this mean?
- Appears to be relatively little coordination with other analysis teams to date.

Specific recommendations and additions or deletions to the work scope

- Consider relaxing the homogeneous demand assumption with a regional model Start planning for detailed regional analysis based on GIS information.
- None.
- Consider adding real data from gasoline station usage.
- Need to include external costs, e.g. GHG emissions. Market reality of investment decisions should be considered – will overcapacity be committed without policy incentives? An interface is needed to a demand model.

Project # AN-02: Impact of Hydrogen Production on U.S. Energy Markets

Harry Vidas; EEA



Brief Summary of Project

The objectives of this project are to: 1) Develop a consistent, integrated framework for evaluation of impacts of hydrogen production within U.S. energy markets using a regionalized version of the MARKAL model; 2) Evaluate costs and timeliness of various scenarios of a developing hydrogen supply infrastructure; 3) Evaluate impacts on U.S. energy markets including price and consumption changes for coal, natural gas, renewables and electricity; and 4) Identify most economic routes and financial risks of hydrogen production.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.1** for its relevance to DOE objectives.

- Not very important to the Hydrogen Vision: definitely not a maker or breaker. Not at all clear how they are going to get to realistic numbers. Examination of regional differences is important aspect of this study. Would be good if they looked at hydrogen versus other approaches to lessening fuel shortages, but in doing so they would need to include the objective function of minimizing carbon dioxide production.
- H_2 influence on energy markets is important.
- Project objectives support the Hydrogen Initiative and provide the MARKAL model with the ability to analyze regional infrastructure impacts.
- The integrated consideration of the transport and stationary energy markets is very important as they draw on similar resources. Market impacts need to be fed back into hydrogen market models.
- Most objectives are in-line with DOE goals, but it maybe too early for this kind of detailed analysis.

Question 2: Approach to performing the research and development

This project was rated **3.0** on its approach.

- At least some aspects of this study don't really seem to directly address the main problem and not well-focused on leading to Go/No-Go decisions. Including impact (feedback) on price/consumption changes for various scenarios is a major plus. Need to look at sensitivity of results to assumed relative efficiencies of hydrogen fuel cell vehicles (FCV) and gasoline internal combustion engine (ICE). Regionalization is a good point. Appears to address question of CO_2 sequestration: this is a plus.
- Combination of models leverages previous work. Modifications to regions for MARKAL is sound approach. Hydrogen modifications were not described in enough detail.
- The approach is well thought out for the fossil input. It lags in the renewables (biomass and renewables).
- The use of existing models is a strength for this project. It avoids waste of effort and questions about validity.
- Not clear that this modeling exercise will translate into understanding of the real world. In reality, there will be too many other consumer drivers that will impact vehicle demand.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **2.7** based on accomplishments.

- Last year's accomplishments are not very clear. How much of this is really new versus how much is plowing old ground. Fairly methodical. The current use of old databases in the project should be reconsidered. Hydrogen vehicles versus year charts appear to be very unrealistically high.
- Progress focused on researching cost estimates for coal, biomass, & sequestration. Project did not show enough progress on the code modifications. Assumption of 3X fuel economy for FCV is not realistic, which will make model predictions overly optimistic.
- There is a concern that progress is slower than desirable, seems to have been a lot of work in 2005/6 but perhaps < 50% of scope addressed at this point in the program.
- Portfolio of models used address very well hydrocarbons, gas, and coal (a 3+ score). Approaches to biomass are not consistent with the DOE Biomass Program and the current Presidential initiative on Biofuels (a score of 2). Approach took data from one publication of the '90s which addressed biomass availability for 2010 and not the current studies that project availability by 2020+. The area already has incentives to accelerate development.
- The next year will be important for this project to produce outcomes.
- Most work was focused on coal. Not clear how this will be used to generate useful results for hydrogen.

Question 4: Technology transfer/collaborations with industry, universities and other laboratories

This project was rated **2.5** for technology transfer and collaboration.

- Not strong in that they don't appear to be involving commercial gas producers or oil and natural gas companies.
- It is not clear how this project will interface with other models being developed in other projects, e.g., demand and feedstock prices into DTI model. Infrastructure design could benefit from consideration of work done at UC Davis/others - appearance is that this is being done in isolation of other potential sources. Could consider natural gas storage as proxy for hydrogen storage rather than storage of liquid transport fuels?
- Collaborations are very appropriate for the fossil energy components. Need more explicit collaboration in the biomass and renewable portions.
- Collaboration in use of existing models is fundamental to the project.
- Closer work with other analysis teams would prevent overlap and duplication of effort. Review with Tech Teams may help drive the analysis towards generating more useful results.

Question 5: Approach to and relevance of proposed future research

This project was rated **2.9** for proposed future work.

- Mostly more of the same, but that's not bad in this case.
- Plans for the next stage are clear and consistent with the remit.
- Apply to the fossil energy inputs not the biomass or other renewables.
- The next year will be important for this project to produce outcomes.
- Interesting modeling effort, but it is not clear that the analysis will yield any results that can be applied to the real world. Therefore, it is not clear how this project will provide a better understanding of how we can develop a H_2 infra.

Strengths and weaknesses

Strengths

- Examination of Inter-regional differences is important. Including impact (feedback) on price/consumption changes for various primary sources is very important. Including treatment of CO_2 sequestration is important plus.
- Project is designed to evaluate H_2 production in the context of other energy markets.
- Thorough and comprehensive methodology, use of MARKAL, development of regional breakdown.
- MARKAL knowledge; models for fossil energy resources are all very good.

- Adds electricity and gas market modeling to the modeling suite – these are critical linkages for hydrogen modeling. Provides the missing feedback loop on market price impacts. Uses a mature energy market models (MARKAL etc).

Weaknesses

- Demand curves on hydrogen vehicles versus time appear badly out of kilter with reality, absent government incentives/policies.
- Progress on model development is not shown. Results after the level of spending to date seem less than expectations.
- I note that crude oil to hydrogen is not an option in the modeling system - this could be gasified just like biomass/coal.
- Lack of explicit knowledge of the biomass field.
- Not clear how the end results will be represented. Needs to be complemented by demand modeling.
- Presenter did not make it clear what the results of the analysis will be and how they will advance DOE goals/understanding. There appears to be little coordination with other analysis teams to date resulting in possible duplication of effort.

Specific recommendations and additions or deletions to the work scope

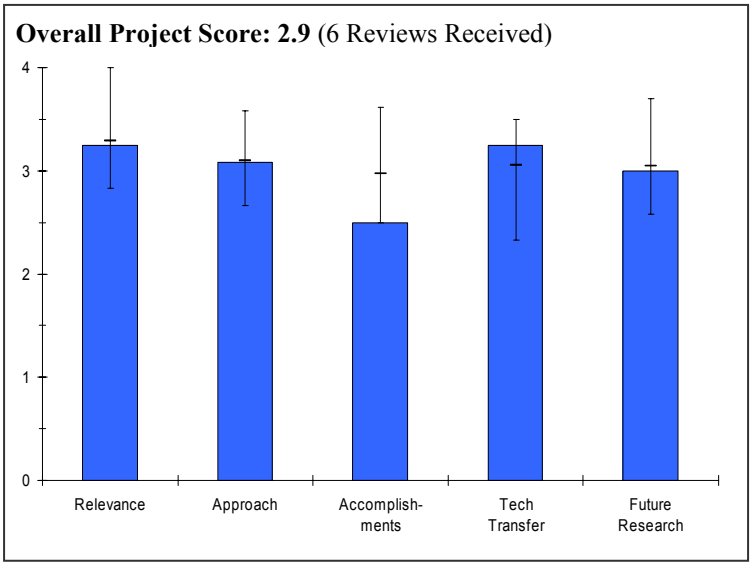
- Need to look at hydrogen vehicles against other fuel-saving options such as optimized plug-in gas/electric hybrids. Needs sensitivity analyses leading to error bars.
- The project would benefit from more integration with other modeling efforts under DOE sponsorship, particularly sharing of inputs and outputs. There appears some duplication, e.g., demand estimates, but I suspect this is not really the case as the estimates are derived from different directions, hence the previous comment.
- Significantly revise the scope/approach in the biomass area. Could collaboration with the DOE Biomass Program be started? The project approach cannot take one data set from the literature of the '90s and project it into the future when there are current potentials for biomass availability that DOE and USDA have published recently for 2020.
- Some technologies are modeled that have uncertain cost - e.g. Geosequestration. The results could be biased by not accounting for uncertainty in technology. Is gasification modeled – bypassing the electricity grid? Storage capacity is an important issue – security of supply. How is optimization achieved? Inclusion of plug in hybrids (ICE & FC) should be considered? Need to ensure assumptions are consistent with other models. Measurement of cost, security and GHG emissions would assist evaluation of scenarios.

Project # AN-03: Analysis of the Hydrogen Production and Delivery Infrastructure as a Complex Adaptive System

George Tolley; RCF, Inc.

Brief Summary of Project

The objectives of this project are to: 1) Use agent-based modeling (ABM) to provide insights into likely infrastructure investment patterns; 2) Deal with chicken-or-egg aspect of early transition; and 3) Provide answer to the question, "Will the private sector invest in hydrogen infrastructure?" These objectives will be met by focusing on investments as business decisions, developing a basis for preliminary assessment of profitability, and preparing an ABM for detailed simulations.



Question 1: Relevance to overall DOE objectives

This project earned a score of **3.3** for its relevance to DOE objectives.

- Infrastructure transition analysis is important to planning the path to H_2 use.
- Addresses a rather key question of "Will the Private Sector Invest in H_2 Infrastructure."
- Interesting and different approach to analysis of production and delivery.
- Agent Based Model is likely to provide good insights to government programs to understand how to decrease investment barriers in new technologies and their infrastructure.
- Consideration of diverse decision making approaches is an important addition to the hydrogen modeling suite.

Question 2: Approach to performing the research and development

This project was rated **3.1** on its approach.

- Agent based model approach is unique and appropriate for making decisions regarding both government and private sector parties.
- Agent-based modeling approach with their premises is excellent. Business Decision Framework is a significant analytical tool for this task. Addresses all-important "chicken-and-egg" question. Seems to be some off-target wandering around rather than homing in on the central issues. Not clear how useful of a tool for others is going to come out of this.
- The project would benefit from a better/more complete understanding of the business goals, particularly their risk profiles and spending practices on companies in this business. Downstream spending by major oil companies is a minimal part of their capital spending budgets.
- Important elements are in the model that has been nearly completed and begins to be exercised.
- The agent based decision making process is an excellent feature to be brought to hydrogen modeling.
- Not enough information on how the model works (i.e. What are the assumptions?) to understand the approach or how results were generated.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **2.5** based on accomplishments.

- The project is just getting started, only 15% of funding. The preliminary results show the approach is viable.

- Seems a little thin on results for the big bucks involved. Not clear that the mapping studies are particularly useful. Reviewing earlier technology penetration rates does not appear particularly useful.
- Difficult to assess overall value while only considering distributed infrastructure. Results and methodology difficult to understand in a short presentation, therefore this leads to doubts about value of results?
- 1) Good example shown of business decision model – case of Posture Plan (government proposal) versus Agent Based Model-BDM driven process with a delay of 5+ years. 2) Somewhat naive lessons from introductions of previous technological innovations. There is a wealth of literature on more germane technological change examples and learning curves for implementation in the energy scenario itself (combustion to turbines). 3) Very good balance of inputs of soft and hard data – social and technical.
- Provides a framework for evaluation of the transition in a manner that takes GIS factors into account.
- Results were shown, but it was not clear how they were generated.

Question 4: Technology transfer/collaborations with industry, universities and other laboratories

This project was rated **3.3** for technology transfer and collaboration.

- Good team of effective collaborators with experience in H_2 system analysis.
- Right types of people included (oil company, gas producer).
- Good list of collaborators but concern over value of their contribution since some assertions don't seem to be valid, e.g., investment levels by major energy companies. Good survey of prior innovation lessons, but is this the same? Later examples like mobile phones might be more valid? Does hydrogen infrastructure have to mirror existing gasoline infrastructure?
- Starting project, coordination among partners can improve. Sharing of basic knowledge like calculation platform should be common knowledge.
- The collaboration in this project is a strength. Clearly the collaborators have made a significant contribution in an area that has been lacking in other models.
- Not clear if this model will be able to be used in/by other projects.

Question 5: Approach to and relevance of proposed future research

This project was rated **3.0** for proposed future work.

- PI appears to be uninvolved in software design. Project should be more closely coupled to Macro-System Model activities to make sure there can be software compatibility.
- The pathforward should be clearly identified which was not obtained from the project presentation.
- How difficult would it be to expand the approach to address central/city gate plants, not just distributed?
- Plan addresses key areas for exercising the models so that policies, decision drivers for industry, consumer behavior can be modeled.
- The next phase of work is important in order for outcomes of the work to be usable.
- Lots of work to do.

Strengths and weaknesses

Strengths

- The agent based modeling approach is a good means of simulating the interests of varying parties involved in the transition to hydrogen.
- Agent-based modeling approach. Good question and premises. Chicken and egg aspect important.
- Interesting approach, allows for uncertainty and learning.
- Agent Based Modeling is a good addition to the tools of the Analysis program. The ability to input "behaviors" of agents and analyze their potential outcomes is a powerful guide to the program.
- Agent based decision process adds a market reality to infrastructure decisions. Decisions will be based on convenience and vehicle costs. Model will include both in and out of town trips. Simulation model link to other models.

Weaknesses

- A clear description of the software issues needs to be presented.
- Looks thin on useful output and on actually answering the well-posed questions.
- No clear path as to how to integrate this work into other analysis work, i.e., captures its value into other work.
- A suggestion to avoid a potential weakness of analyses of such complex multivariable data sets is to use of a situation for which there are data from policy actions on new fuels (e.g., ethanol, COG, etc) and their penetration. One example (ethanol) had a successful policy to achieve a higher penetration and the second not being sufficient. Analyze the role of the alignment of state and local governments to the federal and how much this amplified the federal actions. While retrospective, the ability of the model to predict these outcomes, which resulted in significant industrial investment, would reinforce the value of the model.
- Options not as strong a focus. Not clear how this will interface with other modeling. Not clear what the assumptions or structure of the model are.
- Modal approach and assumptions were not conveyed in the presentation. This made it hard to rate this project. The presentation approach should be evaluated to give a clear understanding of the model.

Specific recommendations and additions or deletions to the work scope

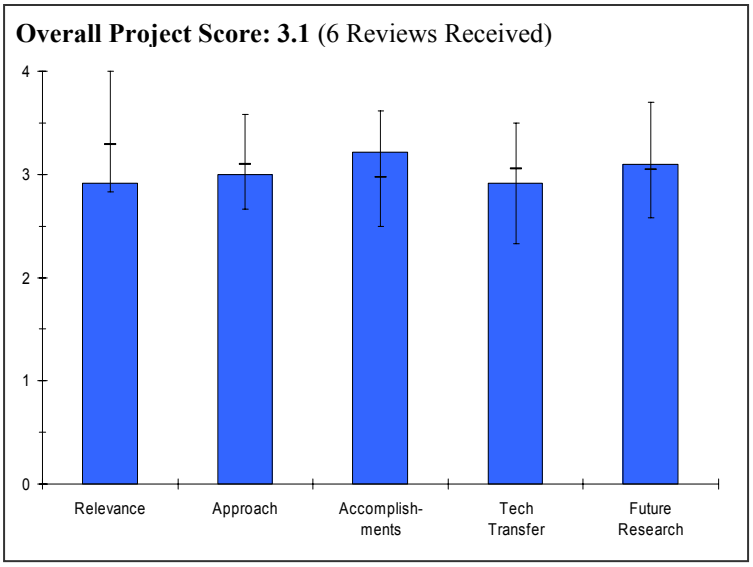
- Couple this project more closely to the Macro-System Model project, at least for planning and coordination purposes.
- None.
- The concept of an advisory group, larger than the project participants, might help guide reasonableness in assumptions. Explicit interactions with other analysis work would help, e.g., demand simulation into DTI work, cost data from other work.
- See above.
- A description of how agent behavior adapts is necessary? Defines the outcome of competition but not necessarily the optimal solution for the economy – central planning vs. competition. Will private sector make these decisions – need to account for policy stimulus – close gap with posture plan by introducing incentives The idea of Government agent was raised as a way to address government objectives. This modeling and collaborators could be used to develop a demand model which is a critical element to the overall modeling suite.

Project # AN-04: WinDS-H2 Model and Analysis

Keith Parks; NREL

Brief Summary of Project

This project is a GIS-based, supply-side hydrogen economy transition analysis. The analysis determines optimum hydrogen production and delivery pathways for cities within a region and calculates delivered hydrogen cost. It will also determine the infrastructure layout for different production/delivery choices and consider electricity sector impacts and contributions to the hydrogen economy.



Question 1: Relevance to overall DOE objectives

This project earned a score of **2.9** for its relevance to DOE objectives.

- Minor contribution at best: not going to be a maker or breaker. Not particularly useful in Go/No-Go decisions. Not really contributing to progress toward a hydrogen transport sector economy.
- Regional analysis is important to understanding the trade-off between H_2 production and delivery options.
- Project relevant since Energy Policy Act of 2005 explicitly requested the understanding of renewables and hydrogen link which has been partially done. For instance, Wind/H_2 was considered hybridized with the grid and not with another compatible renewable.
- Has unique features – regional rather than city based.
- This model addresses the development of hydrogen infrastructure.
- In-line with project funding.

Question 2: Approach to performing the research and development

This project was rated **3.0** on its approach.

- Objectives not unreasonable but scenario is too simple and non-integrated. Overly simplistic. One plus is that it does cost out pathways for different regions.
- Combination of models is a good approach. Correlations from H2A scenarios model simulate delivery options. Model is static, so transition analysis is outside realm of study.
- The model provides visual outcomes that illustrate well infrastructure options, weaknesses, and strengths. Strength is the analyses of distributed systems compared with central production and siting in rural or urban regions and their interface.
- Use of other models and contributors is good. Representation of economies of scale is good. Geographic representation/build out good, especially recognition of distributed technologies occurring in rural areas for longer.
- Integration with GIS capability, H2A and NEMS is a strength.
- Good integration with existing models.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.2** based on accomplishments.

- Maps not particularly informative. Pathway optimization is straightforward and easy to exercise. Presentation charts tended to be confusing.

- Results show realistic options are coal gasification or distributed Steam Methane Reforming (SMR), with SMR necessary at some distance from plant. Michigan study should be compared with some other region of county.
- The model was exercised to provide the spatial link and explore the urban/rural interface. It confirms that for isolated regions distributed hydrogen options will be necessary, that are more costly amongst the technical choices currently in H2A that were used.
- Progress vs. Timetable appears good. Where does the pricing of other feedstocks get affected, e.g., coal?
- The modeling appears to be producing logical results.
- In-line with project funding.

Question 4: Technology transfer/collaborations with industry, universities and other laboratories

This project was rated **2.9** for technology transfer and collaboration.

- Do not appear to be involving appropriate outside people (oil and gas companies, potential users.
- Collaborated with others who developed the models that were linked in this analysis.
- Project completed and integrated the overall program models.
- Good use of other models/collaborators.
- Very strong modeling links.
- These results should be compared to the DTI project and other preliminary analysis results.

Question 5: Approach to and relevance of proposed future research

This project was rated **3.1** for proposed future work.

- Doesn't appear to be worth pursuing further. Simple EXCEL product which simply reads tabular input files seems to be an appropriate endpoint.
- Project is nearly completed.
- Scoring future work not relevant since the project is completed (NA).
- Project almost complete. Would want to ensure that results can be available to other modeling projects.
- The sensitivity analysis is important to ensure that robust results are considered.

Strengths and weaknesses

Strengths
- Essentially none.
- GIS based regional analysis that compares various production options.
- Model developed to illustrate visually infrastructure options for centralized and distributed production. As more distributed options are developed in the program, the model should be updated.
- Good build onto the winds project. I especially like the GIS interface and apparent ease of use.
- Strong linkage to H2A (production and delivery). Integrated GIS, Optimization approach. Supply curve development is powerful. Feedback onto natural gas price – based on NEMS forecast – could link to MARKAL Model. Includes existing hydrogen infrastructure.

Weaknesses
- No clear conclusions. Very little value added.
- Results and conclusions are limited by the analysis of only one region.
- Static and set as competition of three technologies at a time.
- Need to put in demand forecast. Not a criticism per se but it would be good to have a demand forecast project that can be used across the various analysis projects.
- Lacks demand evaluation. Green House Gas (GHG) emissions are not factored in.

Specific recommendations and additions or deletions to the work scope

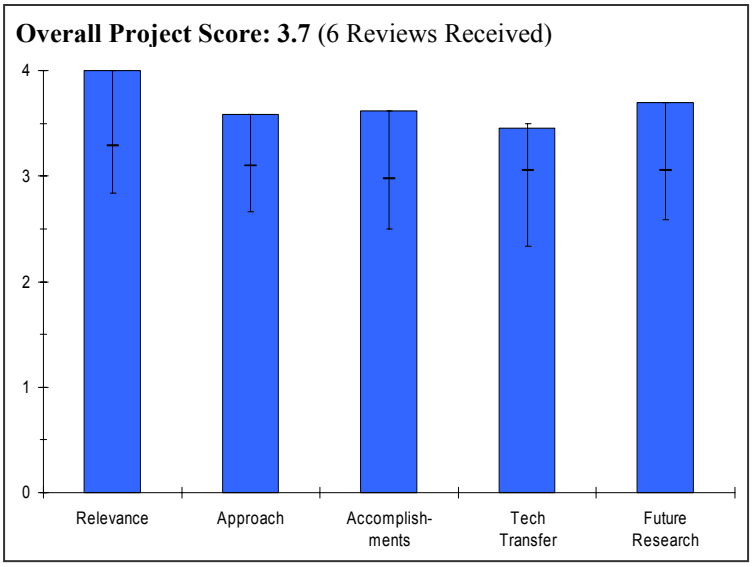
- The project should end.
- Consider what aspects of this modeling effort are applicable for future incorporation into the Macro-System Model.
- I would suggest collaboration with the Energy and Environmental Analysis project (and potentially others) to see how their data/outputs could be integrated with this model.
- Integration with a demand model would make this tool powerful. Modeling of plug in hybrids (ICE or Fuel Cell) could be considered. The objective should include cost, energy security and Green House Gas (GHG) emissions.

Project # AN-05: Macro-System Model

Mark Ruth; NREL

Brief Summary of Project

The overall objective of this project is to develop a macro-system model (MSM) aimed at performing rapid cross-cutting analysis within the Hydrogen Program. It will use high-level architecture to link models being developed or used by the Program. The MSM will generate results that support decisions regarding programmatic investments and focus of future funding. Currently, the H2A, HDSAM, and GREET models have been linked within the MSM framework.



Question 1: Relevance to overall DOE objectives

This project earned a score of **4.0** for its relevance to DOE objectives.

- Excellent approach to quantitatively defining costs in terms of both costs and resource utilization. Should be important in terms of determining whether or not to continue down various paths and in narrowing down options.
- This is crucial work to an overall understanding of the Hydrogen Program.
- Outputs from this model will directly support decisions and direction of the President's Hydrogen Fuel Imitative.
- The integration of all models enabling cross cutting analysis, tradeoff analysis, and support of programmatic decisions.
- Pulling the modeling resources together is critical to the success of the program.
- Has potential to address many technical barriers and questions, but will depend on accomplishments.

Question 2: Approach to performing the research and development

This project was rated **3.6** on its approach.

- Addressing right questions and developing a good systems approach to evaluating and comparing options. Includes policy and incentives and environmental considerations, a strong plus. Analysis of raw material needs also a plus. 2005-2006 objectives and overall objectives very pertinent. Have delineated the important questions very well. Well-to-wheels analysis is excellent feature. Top-notch approach to developing a comprehensive over-arching model of various pathways from well to wheel. Will produce useful product for future users.
- Very analytical approach. I am concerned about how the value of this work can be effectively communicated to the wider stakeholder community. A "layman's" summary could be valuable at regular intervals.
- Selecting the Federated Object Model architecture appears to be the best compromise between a fully integrated model and one that can be developed and used in a reasonable amount of time.
- Very well designed taking input from National Academy of Science (NAS), analysts, the community, and users. Well poised to answer questions on high priority issues for the transition into a hydrogen economy. The approach chosen is well suited for the component analyses that exist and that could emerge with time.
- The linking process has been achieved, with a functional demonstration.

- Very difficult task to integrate these disperse models. The approach appeared to be sound, but it wasn't completely clear how the details will be worked out… presenter should have been given more time to explain this complex project.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.6** based on accomplishments.

- Excellent progress. Interaction with other models is an important facet of this work---integrating existing submodels where possible. Federated Object Model (FOM) architecture is an important feature of this work.
- Progress has been good; expectations similarly high.
- Accomplishments to date, including deciding on a reasonable approach and initiating model development are very good.
- First working prototype was demonstrated and made excellent progress integrating the existing analyses models.
- Progress is consistent with the plan.
- Good progress on a very difficult project. Results need to be compared to other analysis results.

Question 4: Technology transfer/collaborations with industry, universities and other laboratories

This project was rated **3.5** for technology transfer and collaboration.

- Could use more interaction with energy companies and chemical gas producers than is currently apparent.
- Collaboration is key and is being handled well, e.g., analyst workshop, use of other models. Further wider debate could be valuable to the Macro-System Model (MSM) builders, users and audience.
- Collaborations with the other model developers are reasonably good. Bringing in Sandia National Laboratory (SNL) to support Federated Object Model development is an excellent move. Relying on other model developers more could move this rating to "outstanding".
- The collaboration between National Renewable Energy Laboratory (NREL) and SNL has been excellent in enabling the federated model to be implemented. Program participants that developed models (H2A Production, HDSAM, and GREET), have provided input models that now can be exercised by one organization instead of sequentially by several organizations.
- This model is very strongly dependent on other models and is likely to become central to most modeling.
- Now that a framework has been developed, I hope the Tech Team involvement and collaboration will increase.

Question 5: Approach to and relevance of proposed future research

This project was rated **3.7** for proposed future work.

- Very well laid out future plans.
- Early stage work so far. Future plan is thorough and laid out very clearly.
- Priorities for building the model appear very reasonable. Results will provide benefit within two years and benefit growth will follow model expansion after that point.
- Additional models for transportation will be incorporated with time. Spatial, temporal, and consumer models will be incorporated.
- The plan is ambitious but there appear to be many potential options for this models development.

Strengths and weaknesses

Strengths

- Very systematic approach with excellent definition of important issues. Analysis issues categories and prioritization well-defined. Have delineated and posed important questions very well/thoroughly. Well-to-wheels pathway analyses are a major plus.
- Unique modeling effort. Federated Object Model (FOM) approach could allow use of multiple models with common assumptions and philosophies.

- Very good architecture developed and implemented for 3 of the programs. More models will be added.
- Access to the FOM model architecture. Models can be used when linked to the Macro-System Model (MSM) or independently.
- Adopting the FOM architecture and including SNL's expertise to build the model.

Weaknesses

- Could use a little more discussion on how model validation will be performed.
- Complexity of the effort makes QA/(appropriate use) a concern.
- Robustness of the models for multiple users.
- The Macro-System Model (MSM) lacks optimization and decision making structure. User currently specifies the one year situation. Does not represent the transition. There will be a limitation on which models can be used. There does not appear to be a clear consideration of the options for MSM development.
- Not clear that other model developers are being brought in and utilized as well as SNL is.

Specific recommendations and additions or deletions to the work scope

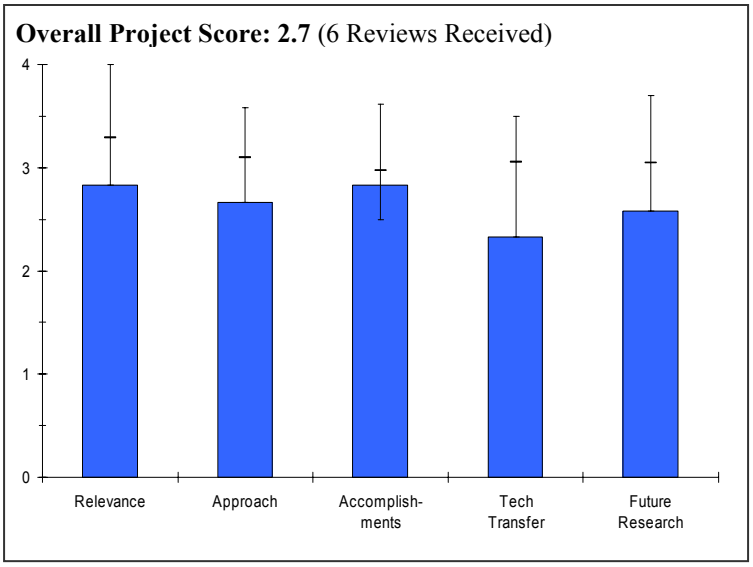
- I would like to see a dedicated project or addition to this one that synthesizes the various analyses and summarizes results in a layman fashion on a regular basis. Many of the individual projects are difficult to understand and have confidence in the outputs. If one group/project were responsible for collating and summarizing, and ensuring common assumptions and philosophies, a coherent summary report series could be produced. I think this could help to inform the wider community and dispel several misunderstandings! Minor quibble - process of liquefying is called liquefaction.
- The Macro-System Model (MSM) could have a decision modeling layer added on top of current model and include an optimization layer above current model The objective function of the MSM could include cost, energy security measure and Green House Gas (GHG) emissions. Future development will necessarily result in more complex structure.
- This is almost certainly the best of the analysis projects.
- Recommended that some way of assigning positive points to reducing global warming emissions be included in comparison with non-hydrogen approaches to alleviating fuel shortages be built in eventually.
- Recommend that NREL concentrate on integration role and depend more on other developers/partners for model and interface development.

Project # AN-06: Geographically Based Hydrogen Demand & Infrastructure Analysis

Margo Melendez; NREL

Brief Summary of Project

This National Renewable Energy Laboratory hydrogen infrastructure development and demand analysis project seeks to quantify hydrogen demand in the U.S. and estimate costs to support infrastructure to meet emerging hydrogen demand. The work focuses on a combination of spatial and temporal assessments to identify the most economic pathways for successfully meeting emerging hydrogen demands. Hydrogen infrastructure transition analysis identifies, describes, and quantifies options for hydrogen refueling during the transition to hydrogen as a transportation fuel.



Question 1: Relevance to overall DOE objectives

This project earned a score of **2.8** for its relevance to DOE objectives.

- This type of analysis appears very mushy, not leading to any means of down selecting approaches. Concept of demand for hydrogen as opposed to demand for fuel in general is not realistic.
- Geographic infrastructure analysis is relevant to the hydrogen initiative.
- Seems to be some overlap with the HyDS project? Both have GIS base, infrastructure rollout. Is demand forecast the key new feature?
- Project is supportive of the Hydrogen Initiative. It adds geographic dimensions to the transitional analyses of the Hydrogen Program and enables visualization of major components of the transition. Demographics evolution, industrial/economic activity, government and private sector ownership, current infrastructure, etc.
- This element of analysis will be very helpful as an input to other models that currently use less sophisticated demand assumptions.

Question 2: Approach to performing the research and development

This project was rated **2.7** on its approach.

- Doesn't really address the very important cost issues (or even feasibility issues). Approach is very fuzzy (unfocused). Their "demographic attributes" maps add very little value. The study seems to take a sociological analysis approach rather than an analysis of cold hard facts (such as costs, infrastructure, requirements, environmental impacts, etc,etc,etc).
- Using GIS to study demographics of likely hydrogen demand is sound approach. Demand seems a bit dependent on assumptions of consumer likelihood to adopt hydrogen vehicles; these assumptions seem reasonable, but are not backed up by any consumer survey information. Weighting the demand factors is somewhat arbitrary.
- Demographic based approach is a useful addition to the analysis suite. Fleet to consumer strategy interesting…but private fleets not like public ones?
- The diagram of page 6 is a very good illustration of what the role of the GIS and resource analysis plays. The degree of integration with other analyses did not come across as well.
- The assumptions don't appear to be market tested.
- This approach is a much better way to estimate hydrogen demand than other approaches.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **2.8** based on accomplishments.

- Not clear what is learned from these maps, which are simply reproductions of easily attainable statistics.
- Results achieved the objective of quantifying hydrogen demand. National maps of demand show varying results with adjustments to the arbitrary weightings. Objectives states cost of infrastructure would be considered, but results to date did not mention.
- Results to date are impressive. Need to be translated and made available for input into other models.
- The project illustrated various factors and provided maps of information that highly depended on the audience knowing the various government programs that exist. It is essential explain the data without excessive jargon.
- The technical framework appears to be strong.
- Good work. Would like to see more integration into other projects.

Question 4: Technology transfer/collaborations with industry, universities and other laboratories

This project was rated **2.3** for technology transfer and collaboration.

- No interactions with those who are going to influence the use of a hydrogen economy are apparent.
- Author is collaborating with experts at Davis and elsewhere. The connection to the Macro-System Model (MSM) is not clear.
- Most of the collaborations include universities and laboratories. Input from industry could be explored further.
- There is a lack of real market input.
- More collaboration with other analysis groups and make model or at least results available to the public.

Question 5: Approach to and relevance of proposed future research

This project was rated **2.6** for proposed future work.

- It actually appears that this project is coming to an end, thus, future plans are not appropriate.
- Future research will consider costs of infrastructure.
- Project almost complete. Would want to ensure that results can be available to other modeling projects.
- Focus on specific examples of policy-alternative fuels geographic deployment (e.g., alternative fuels or ethanol) to show the geographic/technology interactions. So far, data are to be interpreted by the readers and the case has to be done in the analysis to show the links e.g. distributed versus centralizes is a good example.
- Looks good. I am looking forward to seeing final results and using them in other analyses. Results should be prepared in a way that they can be critiqued and used by other analysis projects, e.g. Statistical approach.

Strengths and weaknesses

Strengths

- None.
- Using GIS data for national and regional study of the hydrogen infrastructure is a good approach.
- GIS representation very easy to comprehend, ability to scale down to more detailed areas good. Approach using customer characterization is useful. Effect of policies surprisingly good although not explained in any detail!
- Very good GIS capability and coupled databases
- Focus market behavior. Sensitivity analysis on take up is quite helpful.

Weaknesses

- The GIS information is used to apply a demand expectation that will be logical. It has some arbitrary weighting factors built in. It would help if these factors could be justified by any kind of survey information.
- Linkages to technologies and policies need to be made to show value of the analyses to general audiences (not all audiences understand renewables disperse nature).
- Behaviors appear to be assumed but could be strengthened with market research or analogous market behavior (ethanol or Hybrid take up behavior). Refueling locations are assumed to be near homes. The project AN3 approach may be more valid. Need to take account of route utilization and how demand spreads based on routes traveled.

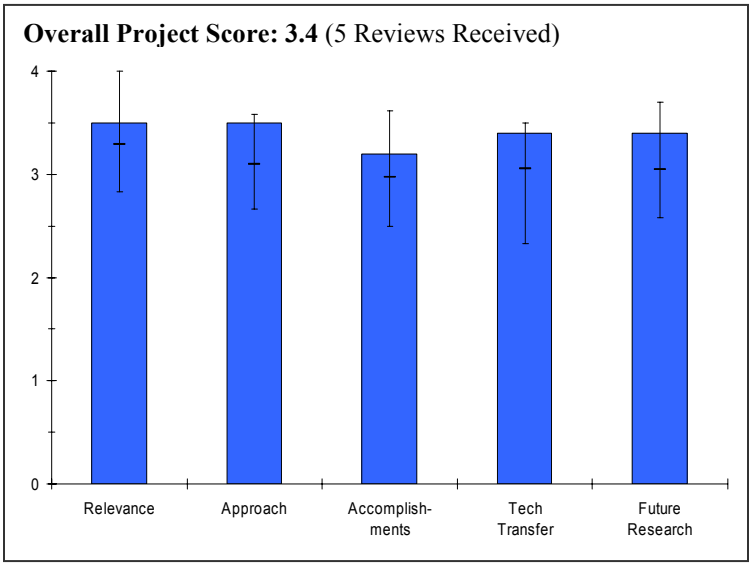
Specific recommendations and additions or deletions to the work scope

- This GIS-based project should be directed to start thinking about how to coordinate with the Macro-System Model (MSM) efforts.
- Collaboration with HyDS project going forward would be valuable to both projects - a combined project extension might make sense.
- The model would be strengthened by integration with the approach used in project AN3 (Agent Based Model project). There needs to be some market testing to confirm assumptions - perhaps by collaboration with project AN3 (Agent Based Model project) parties. Fleet data could be better accessed though automotive industry collaboration. Description of the weighting of factors attributes used in assessing demand would be helpful? UC Davis work on infrastructure development may be useful in developing fuel station infrastructure requirements resulting from the demand.

Project # AN-07: Hydrogen Transition Modeling and Analysis: HYTRANS v. 1.0

Paul Leiby; ORNL

Brief Summary of Project



Oak Ridge National Laboratory has created a working version of an integrated model of the market's transition to hydrogen as a transportation fuel using non-linear optimization methods. The model includes representation of 1) hydrogen production and delivery; 2) vehicle production, including technological progress, scale economies and learning-by-doing; and 3) demand for vehicles and fuels, including the effects of fuel availability and diversity of vehicle choice. Future development will focus on continuous improvement of model components, producing a regional model, generating plausible scenarios of the transition to hydrogen based on DOE Multi-Year Program Plan (MYPP) goals and other technology forecasts, and publishing model documentation and scenario analyses.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.5** for its relevance to DOE objectives.

- Clear alignment to DOE plan goals.
- Looks like one of the two best approaches to reaching logical conclusions about the future of hydrogen usage in the transportation sector and to the narrowing down of optional approaches. Market transition analysis is an important aspect of this study.
- Project integrates major components of the transition to a hydrogen economy. It is being exercised to provide data on the early transition to guide policy development.
- Appear to have several facets that are analogous to the Macro System Model but has optimization over a transition period also.
- Duplication of effort.

Question 2: Approach to performing the research and development

This project was rated **3.5** on its approach.

- Integration of consumer choice and effect on hydrogen demand and costs, etc., is very good.
- Very good approach to analyzing various scenarios and homing in on optimal approaches to hydrogen utilization. Inclusion of policy/incentive scenarios is a strong plus. Adding finer granularity to the early transition years is important, also. Addressing the question of availability of various starting energy sources by region is a plus. Maximization of total consumption benefit minus production, distribution, and other costs is a very important concept.
- Well designed and flexible to address evolving program needs.
- Modeling techniques address need to assess transition.
- Didn't hear anything about the consumer choice model, but from what i've seen in the past, it does not look like it would yield interesting results.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.2** based on accomplishments.

- Good progress, ease of understanding of model and results has improved.
- Looks like good initial progress toward putting the model together. Showing that they understand how the complexities involved in comparing scenarios have to be included. Results indicating an intermediate transition to plug-in hybrids, and a later transition to hydrogen utilization, reflects realism in their modeling.
- Has many attributes that can be varied and copes with very large uncertainties in cost data. The model is incorporating risk measures. Major plus of the project is incorporating international dimensions.
- Appear to just be using and showing other model results. Not sure what value was added by HYTRANS. No new insights were proposed.

Question 4: Technology transfer/collaborations with industry, universities and other laboratories

This project was rated **3.4** for technology transfer and collaboration.

- Collaboration with H2A etc., is good. Is there a plan to coordinate inputs/outputs with other models, e.g., HyDS?
- Not clear that they have adequately included representatives of the user community, but planned meeting with automakers (see Proposed Future Research) should alleviate this.
- Has many partners and reviewers and actively recruits sources of input and review.
- Excellent integration of H2A Greet etc.
- Using lots of other analysis results, but not necessarily performing significant original work.

Question 5: Approach to and relevance of proposed future research

This project was rated **3.4** for proposed future work.

- Plan for this year is good. Regionality plus better representation of consumer choice, fuel availability, etc., is good. One caution - fuel availability does not have to replicate existing infrastructure, especially given potential difficulties of actually installing a small diameter urban pipeline system.
- Good logical plans for future work. Plans to meet with automakers is an excellent plus.
- Good plan.

Strengths and weaknesses

Strengths
- Interesting application to early transition analysis i.e. Sig Gronich's work.
- Looking carefully at a broad range of potential scenarios. Maximizing consumption benefits minus production, distribution, and other costs is a major asset.
- See above
- Combined short and long term transition. Links to other key models. Inclusion of cost, energy security and Green House Gas (GHG) emissions measure of outcome.

Weaknesses
- The waterfall plots are confusing. I recommend the project come up with better way of depicting outputs/conclusions. Need clearer presentation of results and stated conclusions as to identify the strongest scenarios and should be down-selected.
- Presentation package should have a minimum self standing set of slides. Then in the background they could add many more materials but with more connecting explanation. Avoid errors in chart titles.
- Does not represent spatial demand and delivery.
- Does hydrogen cost take into account level of utilization and stranded assets?
- Is there overlap with some of the representation of the H2A delivery model – didn't Directed Technologies Inc. project and HyDS do the same exercise?

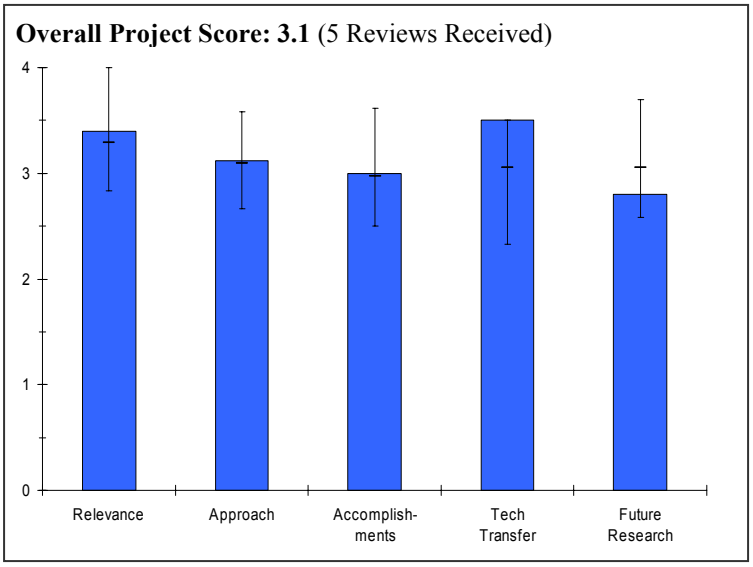
Specific recommendations and additions or deletions to the work scope

- Interaction with other modeling efforts to validate inputs/outputs and results would be beneficial, e.g., Directed Technologies Inc. production analysis, HyDS for spatial demand, increased regions.
- Vehicle technology assumptions to be validated.
- Plug in hybrid potential – impacts balance of electricity and direct energy to hydrogen sources.

Project # AN-08: Hydrogen Analysis Resource Center (HyARC)
Marylynn Placet; PNNL

Brief Summary of Project

The objectives of the project for FY06 are to develop a publicly-accessible, web-based hydrogen analysis resource center to provide ready access to a wide range of consistent and high-quality data and tools for use in hydrogen-related analyses. The website was completed and populated with a range of data and calculator tools that can assist in analysis of hydrogen and fuel cell topics. Links to other analysis tools were also included in the website.



Question 1: Relevance to overall DOE objectives

This project earned a score of **3.4** for its relevance to DOE objectives.

- Definitely not on the critical path. Appears to be a collection of data from various sources, including a bunch of links, and some trivial calculation procedures.
- A very valuable resource. Should be a good archive going forward, provided information can be located as needed.
- Project relevant to the program disseminating proper tools for consistent and high quality tools for use in hydrogen-related analysis.
- An excellent platform for common access to data, assumptions and models.
- Site should improve consistency among analysts and public.

Question 2: Approach to performing the research and development

This project was rated **3.1** on its approach.

- The project had very little detail. It is hard to see how this is filling a critical need.
- I had two issues; some difficulty in finding things, and question of spreading the word beyond just the analysis community!
- Development of consistent tools and their web dissemination is a sound approach.
- Web based resource centre is quite effective.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.0** based on accomplishments.

- Accomplishments appear to be somewhat trivial. I question if this data base is unique.
- Considerable progress for just one year!
- Rapid prototype development and review.
- Useful resource centre available now!
- Some of the calculator tools may allow for abuse by users who are not familiar with input assumptions. Perhaps focus more on raw data rather than tools that come with a lot of assumptions.

Question 4: Technology transfer/collaborations with industry, universities and other laboratories

This project was rated **3.5** for technology transfer and collaboration.

- Having Chevron and Praxair involved in the project is a plus.
- Community peer review process was good.
- Many reviewers included and all kinds of organizations.
- Data in resource centre is dependant on collaborations.

Question 5: Approach to and relevance of proposed future research

This project was rated **2.8** for proposed future work.

- Very vague.
- Links to DOE funded hydrogen analysis work reports should be accessible via this site. Perhaps some safety/educational information could be included/accessible via the website.
- Maintenance and update of the web site as appropriate is a reasonable plan.
- Should spend some time/funds for additional review of the information and tools on the site with an eye towards how someone might misuse the information/tools

Strengths and weaknesses

Strengths
- None
- Good single point source for hydrogen related data.
- Well vetted, validated tools on the web available to analyses of hydrogen options.
- Scope of information is well structured and covers the key areas of interest. Flexibility to consider new content. Responsiveness to feedback. Links to other resources. Provides a basis for consistency in work in the hydrogen program.

Weaknesses
- Doesn't seem to advance state-of-the-art whatsoever.
- The linkage to external sources that may not have same basis - quality and scope fit.

Specific recommendations and additions or deletions to the work scope

- Is there an international component, i.e., data from non US sources that could be linked as well? E.g., CUTE program, Japanese infrastructure trials? Will this be the access point for project reports, including search capabilities? Are there lists/databases of Fuel Cell/Hydrogen ICE vehicles, infrastructure installations (Fuel Cell Today has something like this and H2EXPO [I think])? Links to manufacturers sites, e.g., reformer/compressor/dispenser makers (not sure I agree with this actually)?
- The site visits are being monitored. If it were possible to differentiate site visits of industry, academia, and government, it might give additional insights on the value of the site and possible directions for future updates of the site.
- Ongoing maintenance and additions.