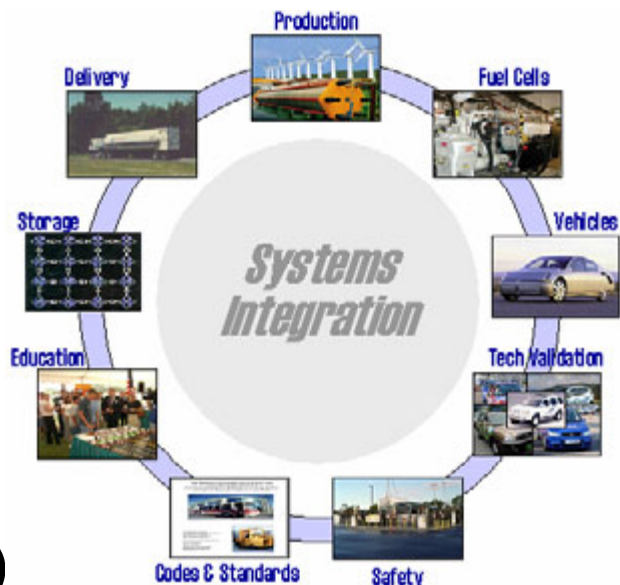


Macro-System Model



Mark Ruth (NREL/SI)
Keith Vanderveen (SNL)

May 18, 2006

This presentation does not contain any proprietary or confidential information



Timeline

- Start date: Feb 2005
- Completion: Sept 2010
- Percent complete: 15%

Budget

- Total funding:
 - 100% DOE funded
- FY05 funding:
 - \$170K NREL/SIO
 - \$50K Sandia NL
- FY06 funding
 - \$276K NREL/SIO
 - \$280K Sandia NL
 - \$60K other national lab work

Barriers

- Lack of consistent data, assumptions and guidelines (B)
- Lack of a Macro-System Model (C)
- Stove-piped/siloed analytical capabilities (D)

Partners

- Sandia National Laboratory (computational development)
- NREL (inclusion of H2A Production & well-to-wheel analysis validation)
- ANL (inclusion of HDSAM & GREET & well-to-wheel analysis validation)
- Others to be identified

Project Objectives

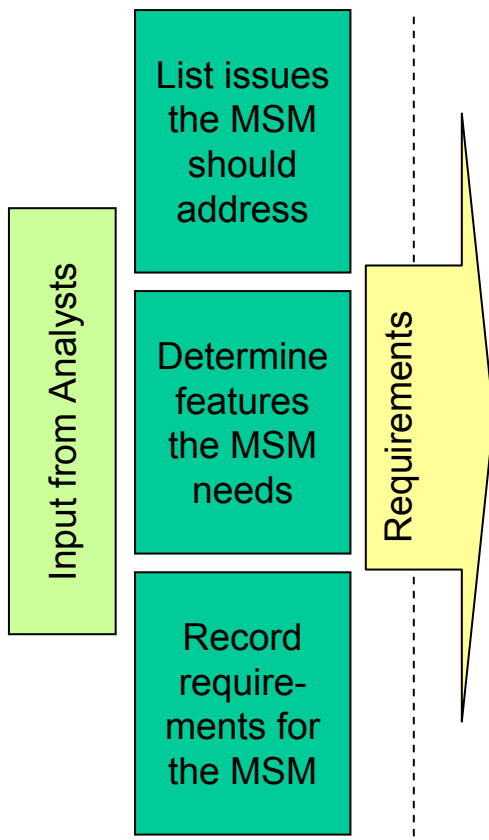


- **Overall objectives**
 - **Develop a macro-system model (MSM) aimed at**
 - **Performing rapid cross-cutting analysis**
 - Utilize and link other models
 - Improve consistency between models
 - **Supporting decisions regarding programmatic investments and focus of funding**
 - **Supporting estimates of program outputs and outcomes**
- **2005/2006 objectives**
 - **Define analysis issues / model requirements**
 - **Evaluate alternatives for the MSM structure and select an approach for development**
 - **Initial integration of models**
 - **Initial analysis: Comparison of hydrogen production/delivery pathways**
 - **Begin validation**

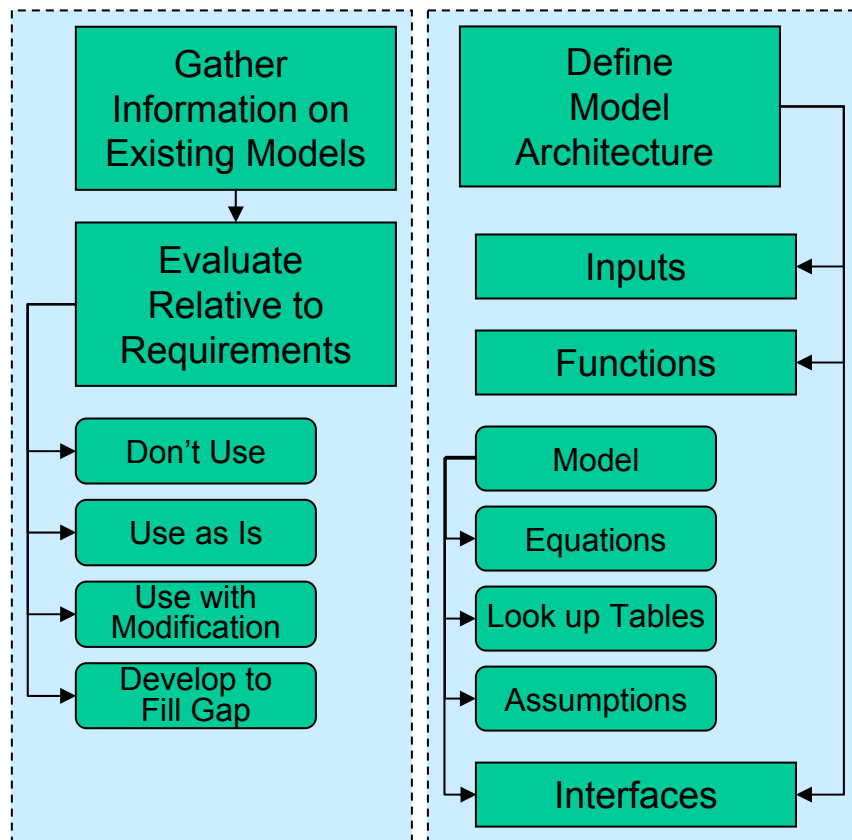
MSM Development Approach



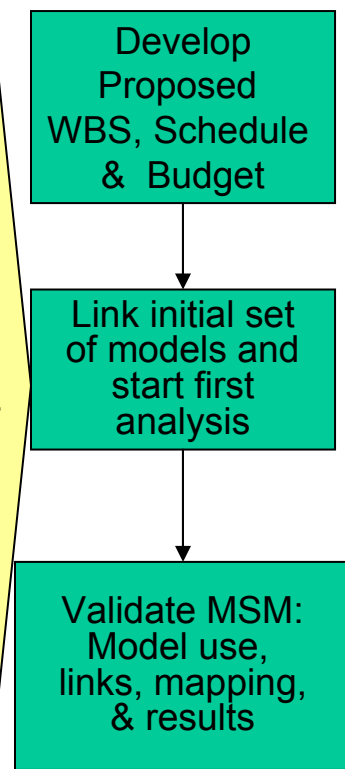
I. Define Requirements

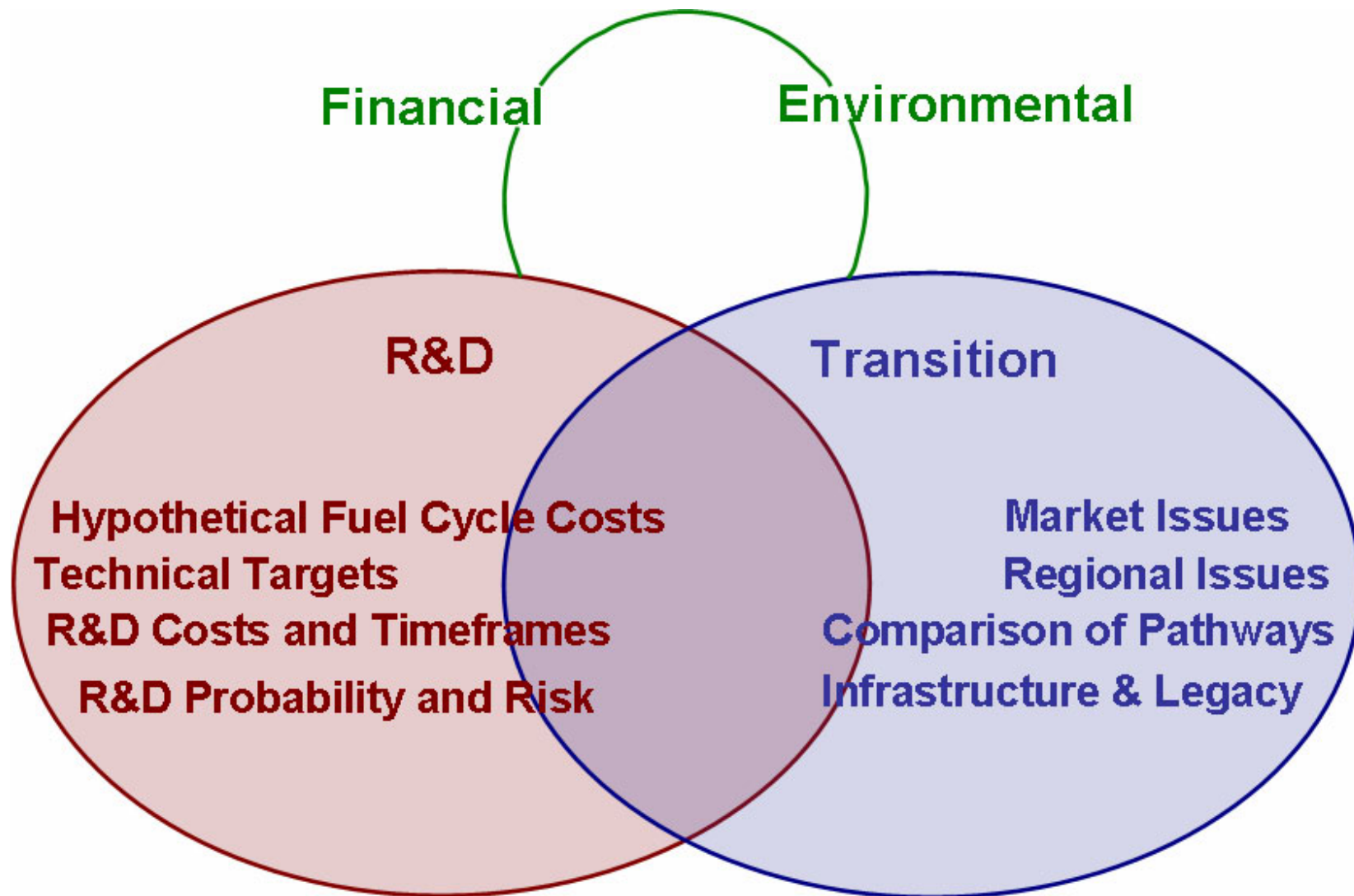


II. Evaluate Alternatives

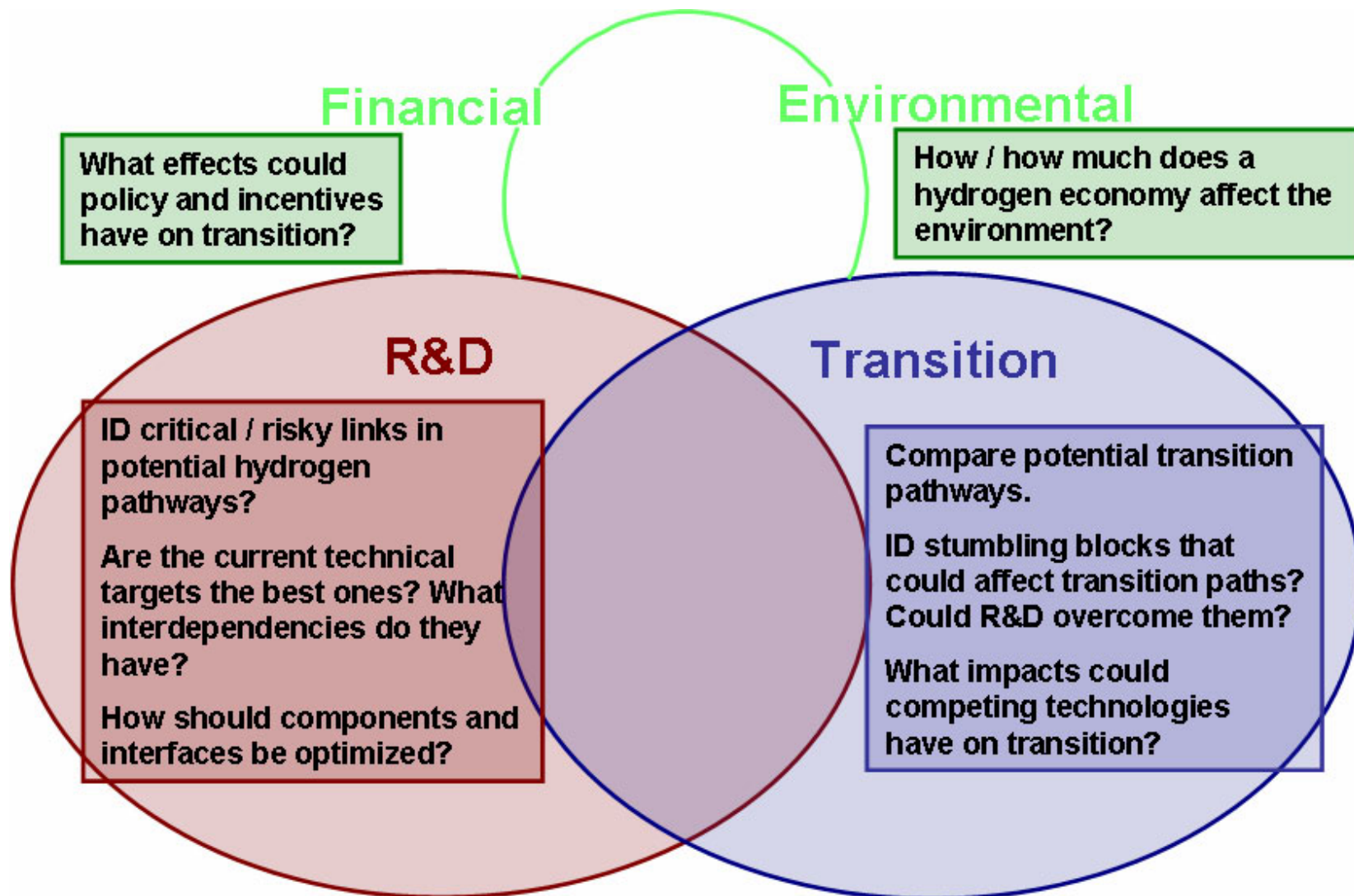


III. Begin Development

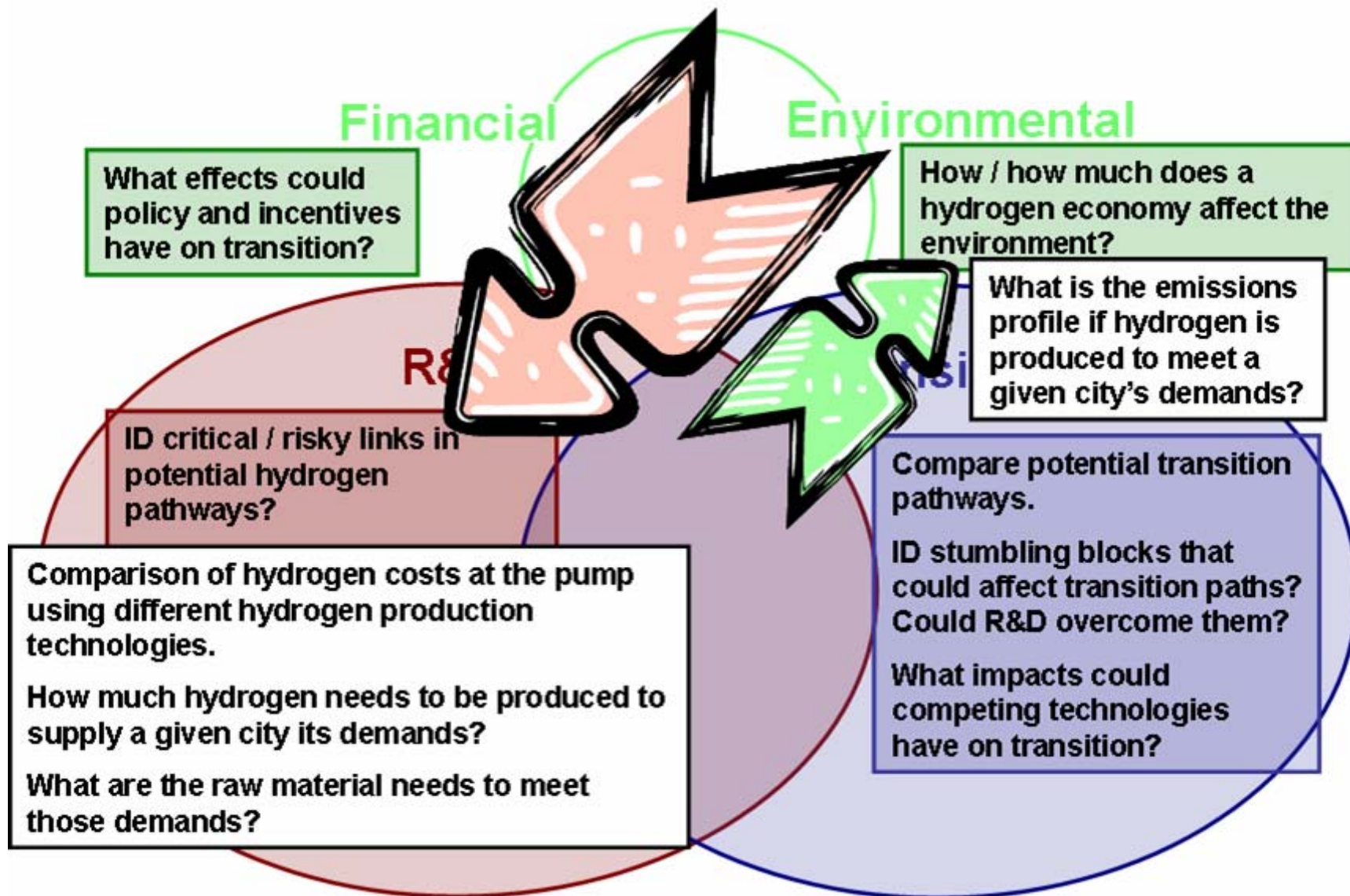


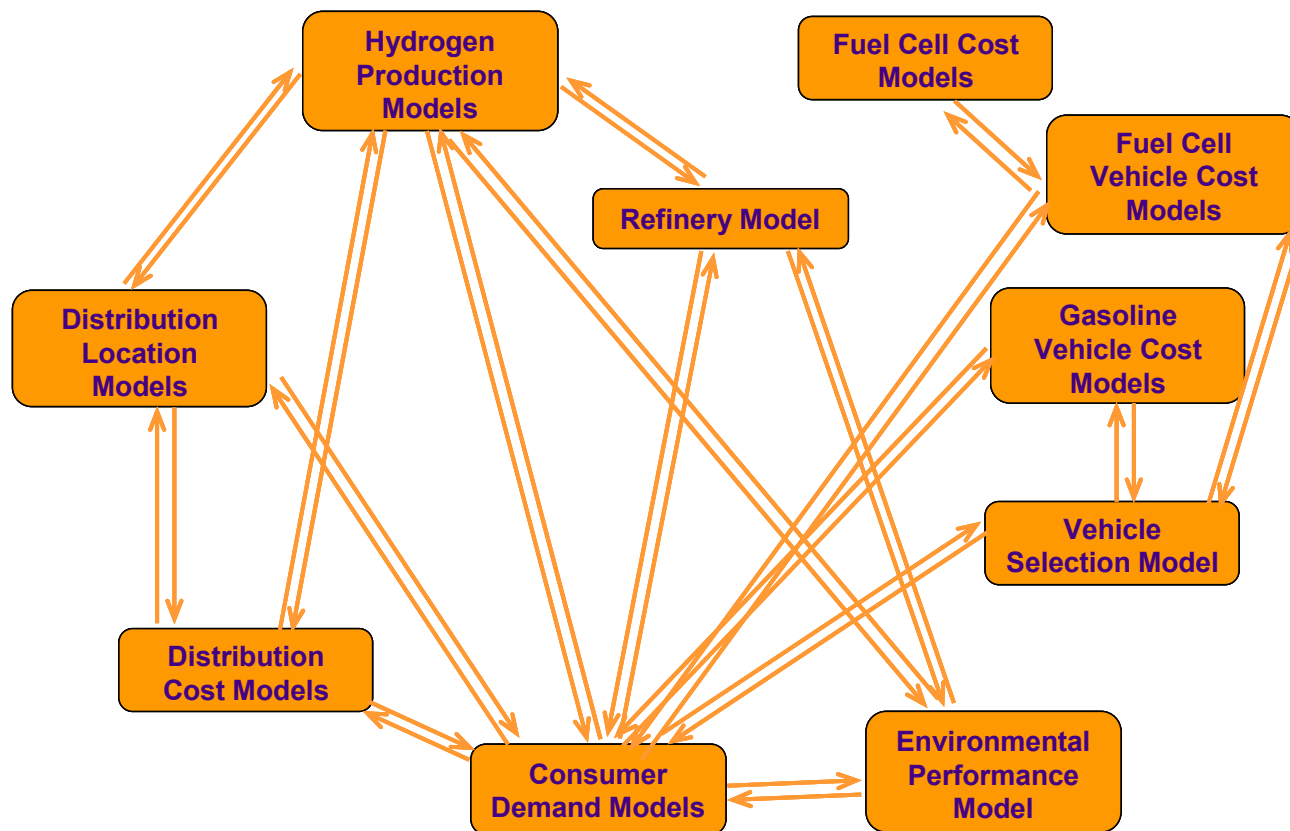


Progress: High Priority Issues



Progress: Initial Analysis Issues





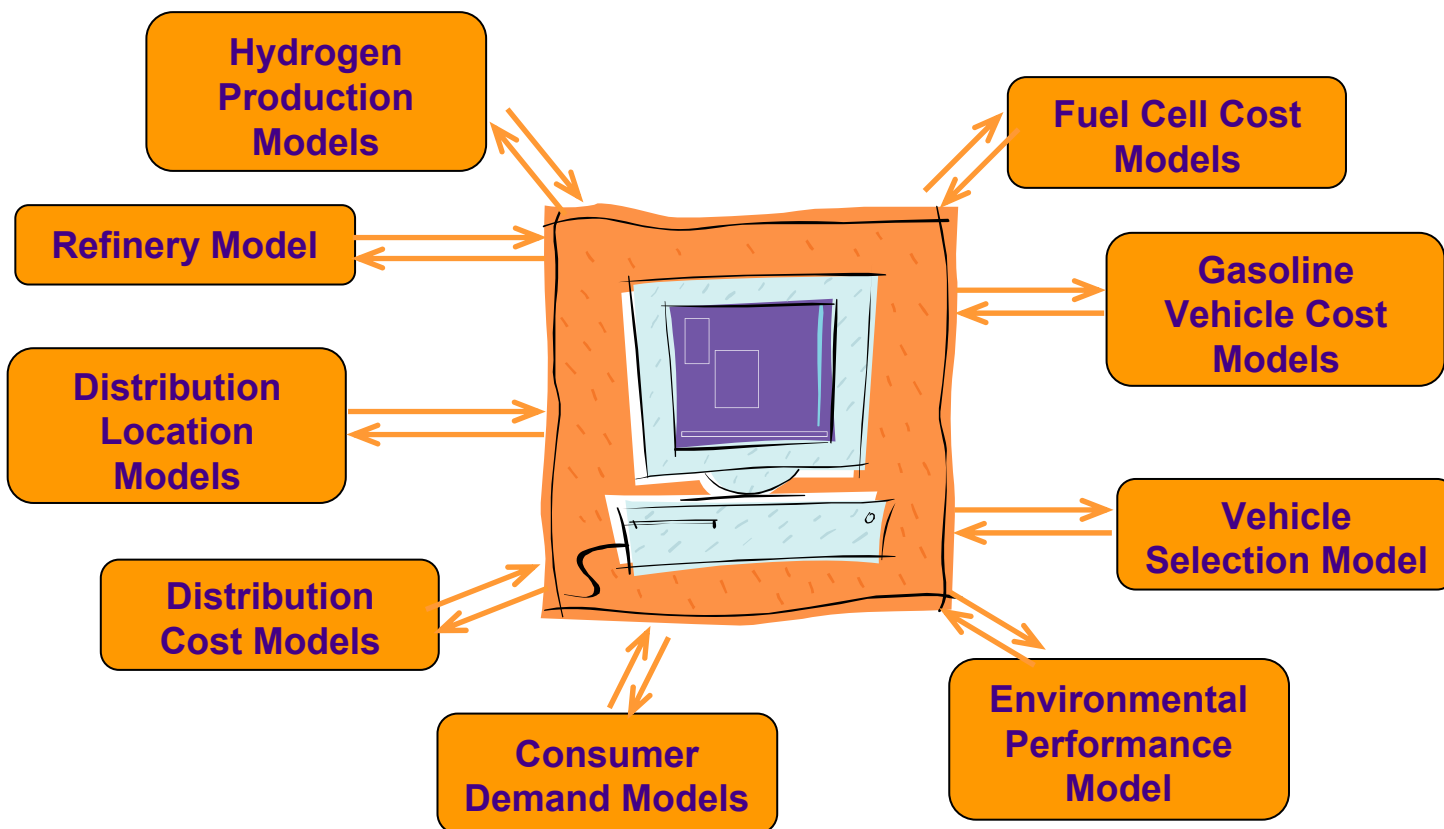
- **Option 1: A new model could be built that captures information from all other models and the interactions between them**
- **Option 2: Model interactions could be defined and interfaces between them could be built**

Progress: Selected MSM Approach

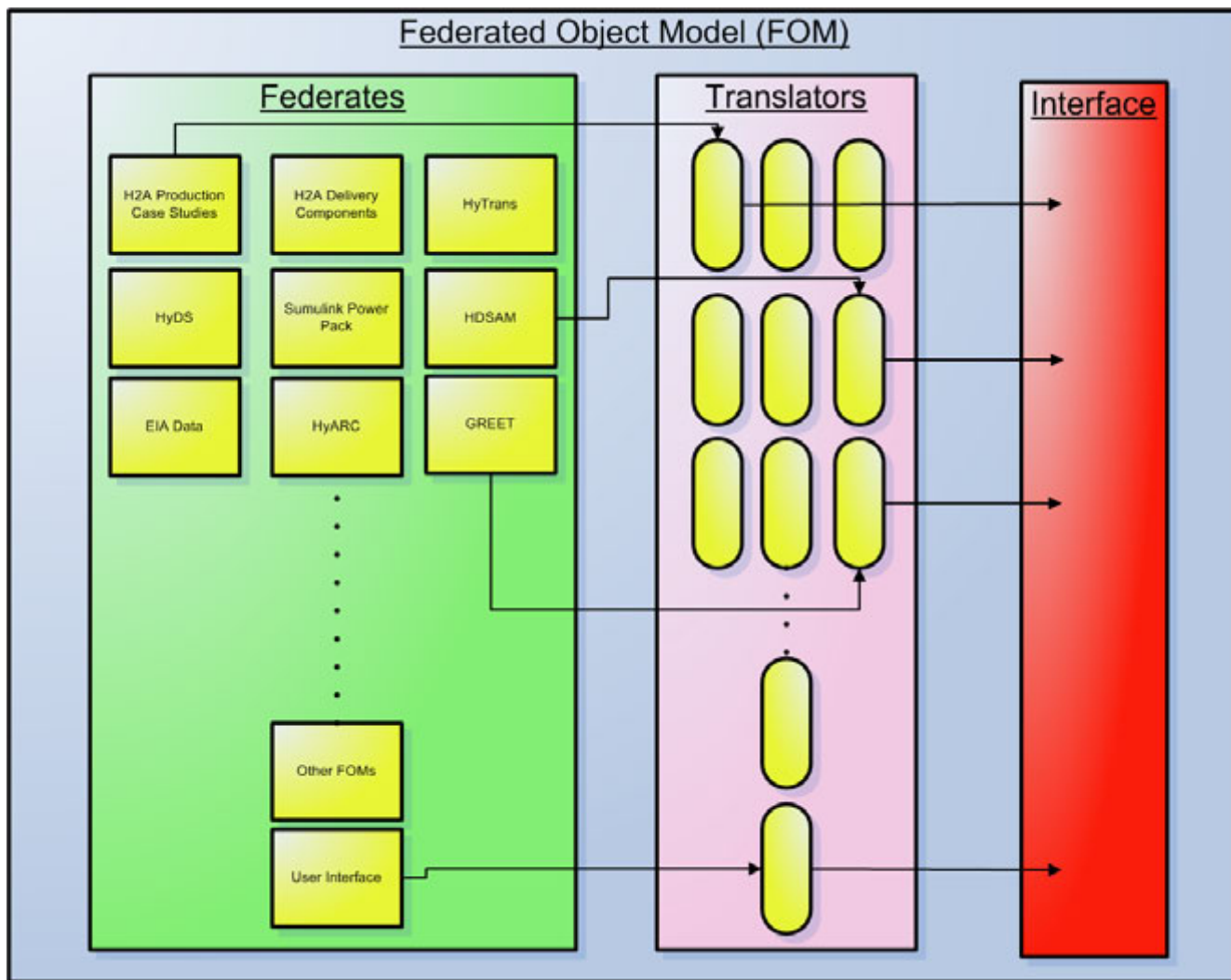


Federated Object Model (FOM) – capable of integrating and utilizing existing and emerging component models (federates) to the extent possible

Standard inputs, credible / documented data, and outputs can be shared between models utilizing a single interface



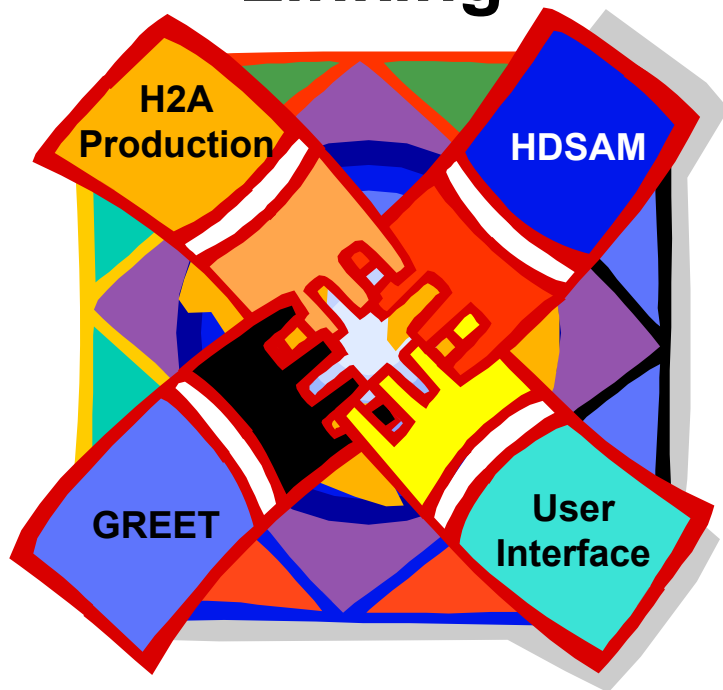
FOM Architecture



- **Translators and interface currently in a single Excel workbook**
- **Java/COM is used to transfer information into translators**

Progress: Initial Model Integration

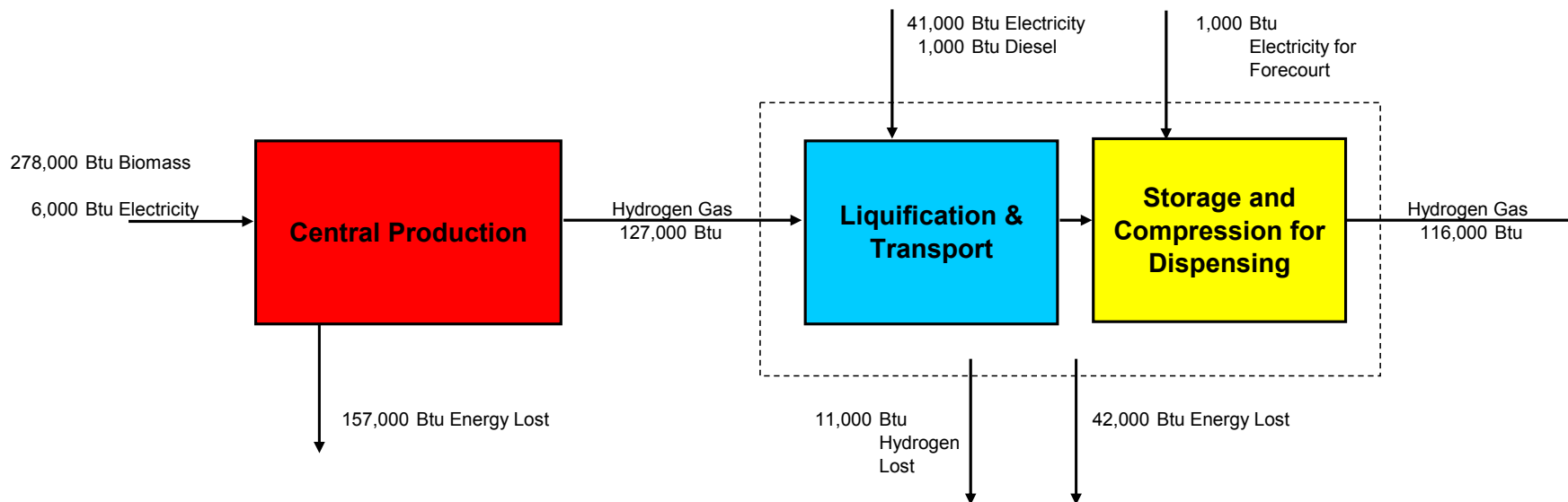
Currently Linking



- Information that needs to be transferred has been identified
- A linking interface has been developed in Excel
- Sandia has developed a Java/COM application to transfer data between the linking spreadsheet and the models
- The Java/COM application also launches VBA macros in models
- Links are being reviewed by model developers

Pathway Well-to-Wheels

Hydrogen Produced In Central Plant and Transported as Liquid via Truck



Well-to-Wheels Total Energy Use (Btu/mile)	7,133
Well-to-Wheels Petroleum Energy Use (Btu/mile)	206
Well-to-Wheels Greenhouse Gas Emissions (g/mile)	-5
Profited Cost of H2 at Pump (\$/GGE)	5.23

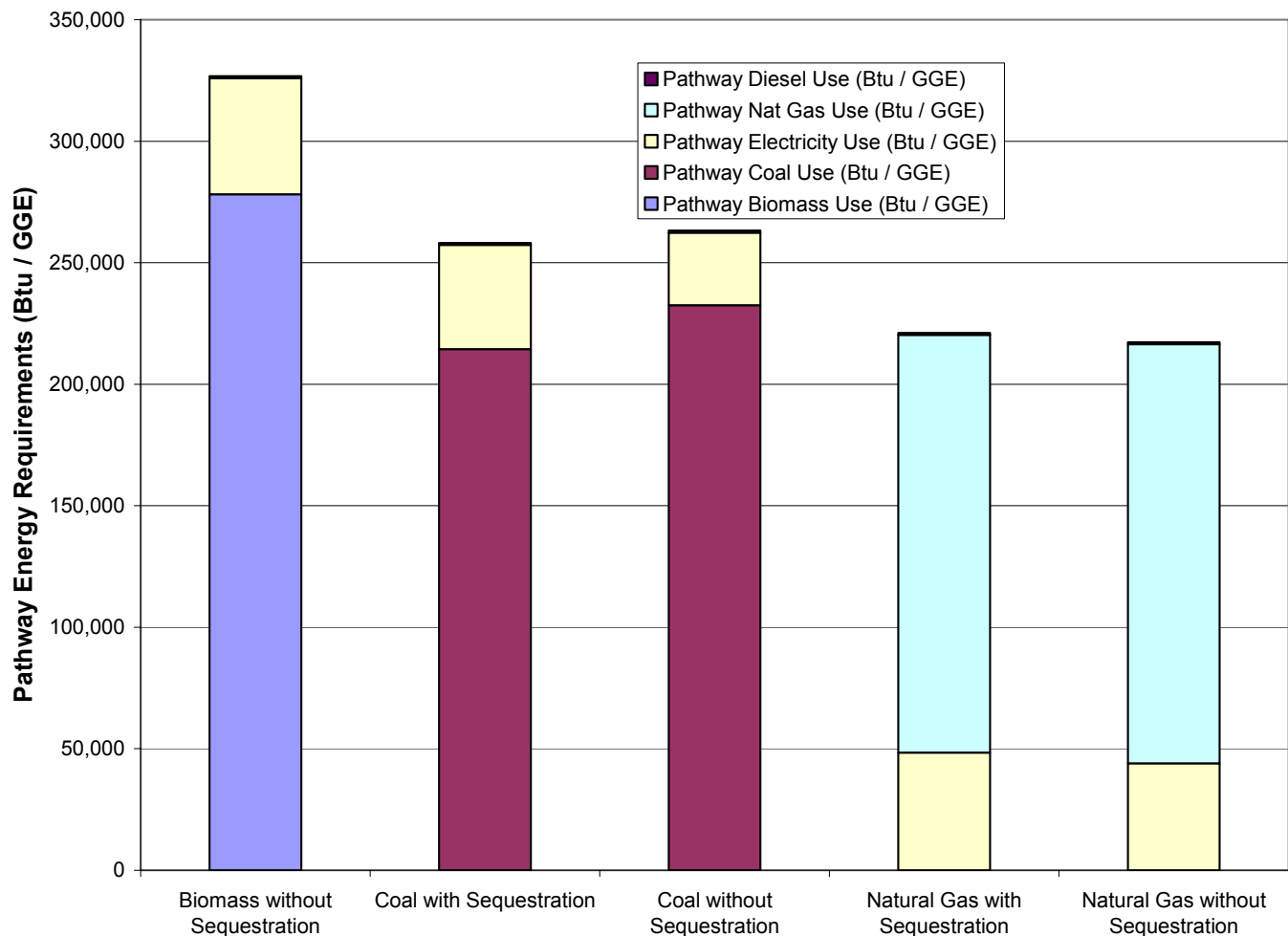
Production Process Energy Efficiency	45%
Pathway Efficiency	35%
WTP Emissions (g CO2 Equivalent / GGE fuel available):	-1

Case Definition

Year: 2005
 Hydrogen as Liquid
 Central Production
 Woody Biomass Feedstock
 Sequestration: No
 Transport for Delivery: Truck

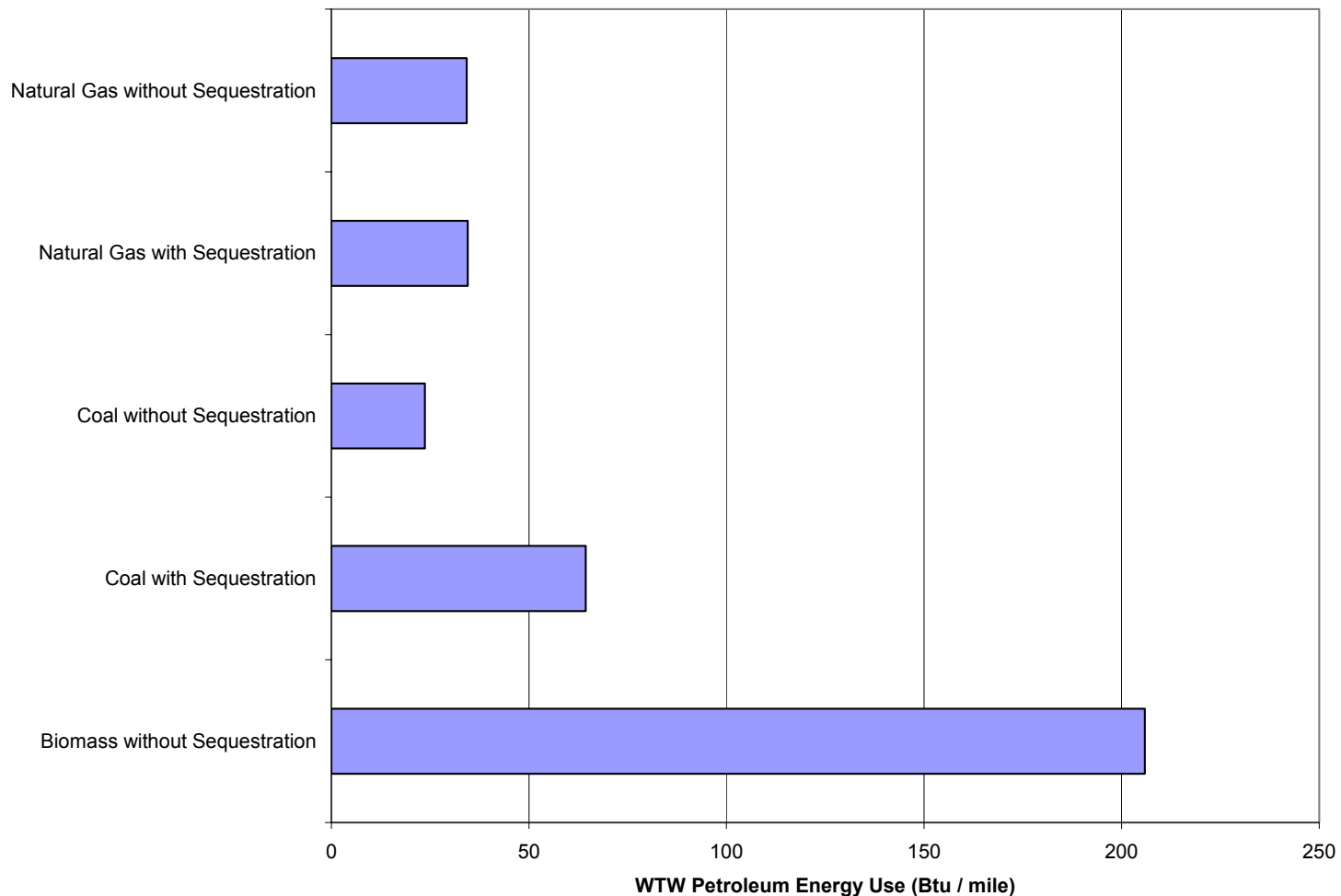
Do not cite: Results shown are preliminary and require validation/correction. They are only intended to be examples of the type of results the MSM will generate.

Energy Sources for Hydrogen Pathways



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Petroleum Requirements for H₂ Pathways

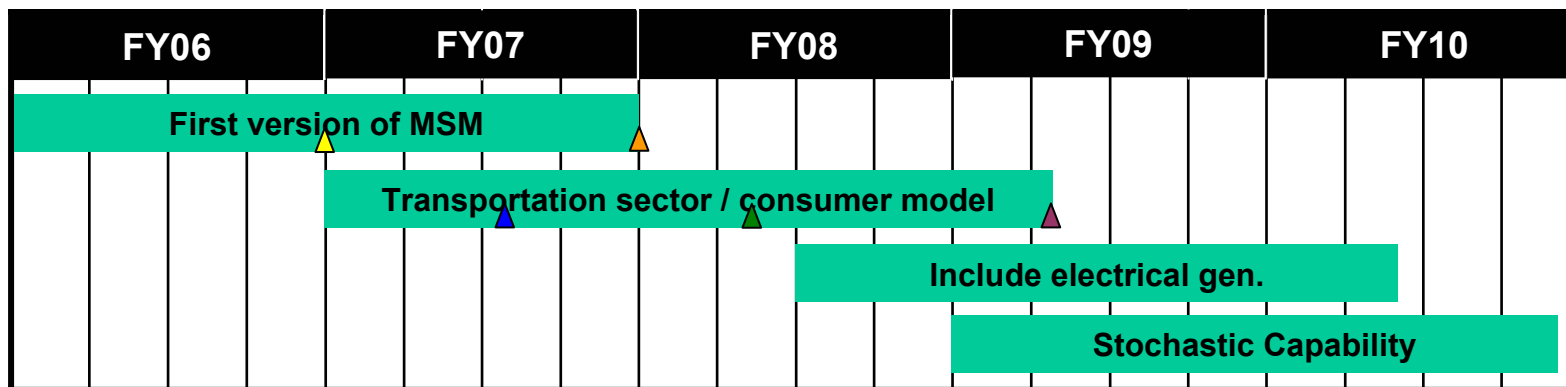


Do not cite: Results shown are preliminary and require validation/correction. They are only intended to be examples of the type of results the MSM will generate.



- **Discussions with model developers**
 - Determine that parameters are being addressed properly
 - Verify that the mapping of links between models is correct
- **Comparison to other analyses**
 - Explain differences between results when they are different
- **Analysis community symposiums**
 - Presentations by analysts
 - Discussions of methodology
 - Develop consensus on proper modeling approach for each analysis issue

Future Work



- **First version of the MSM (H2A Production, HDSAM, GREET)**
 - Validation of the MSM
 - ▲ Initial analysis of production/delivery pathways (September 30, 2006)
 - Create a friendly user-interface for the MSM
 - ▲ Make MSM available on password protected internet site (September 28, 2007)
- **Integrate transportation sector / consumer models into MSM**
 - Determine next set of issues that need to be addressed
 - Add of temporal and spatial aspects to the MSM
 - ▲ Include either HyDS or HyTrans (April 30, 2007)
 - ▲ Include the model not chosen previously (April 30, 2008)
 - ▲ Review transition strategies using the MSM (January 31, 2009)
- **Include stationary electrical generation and infrastructure for a full hydrogen economy (February 28, 2010)**
- **Include stochastic modeling capability (August 31, 2010)**

Summary



- **The MSM is being built to address priority analysis issues**
- **The Federated Object Model approach is being used to develop the MSM**
- **H2A Production, HDSAM, and GREET have been linked in the initial version of the MSM**
- **Preliminary results have been generated**
- **Validation of the MSM and development of a user interface are underway**

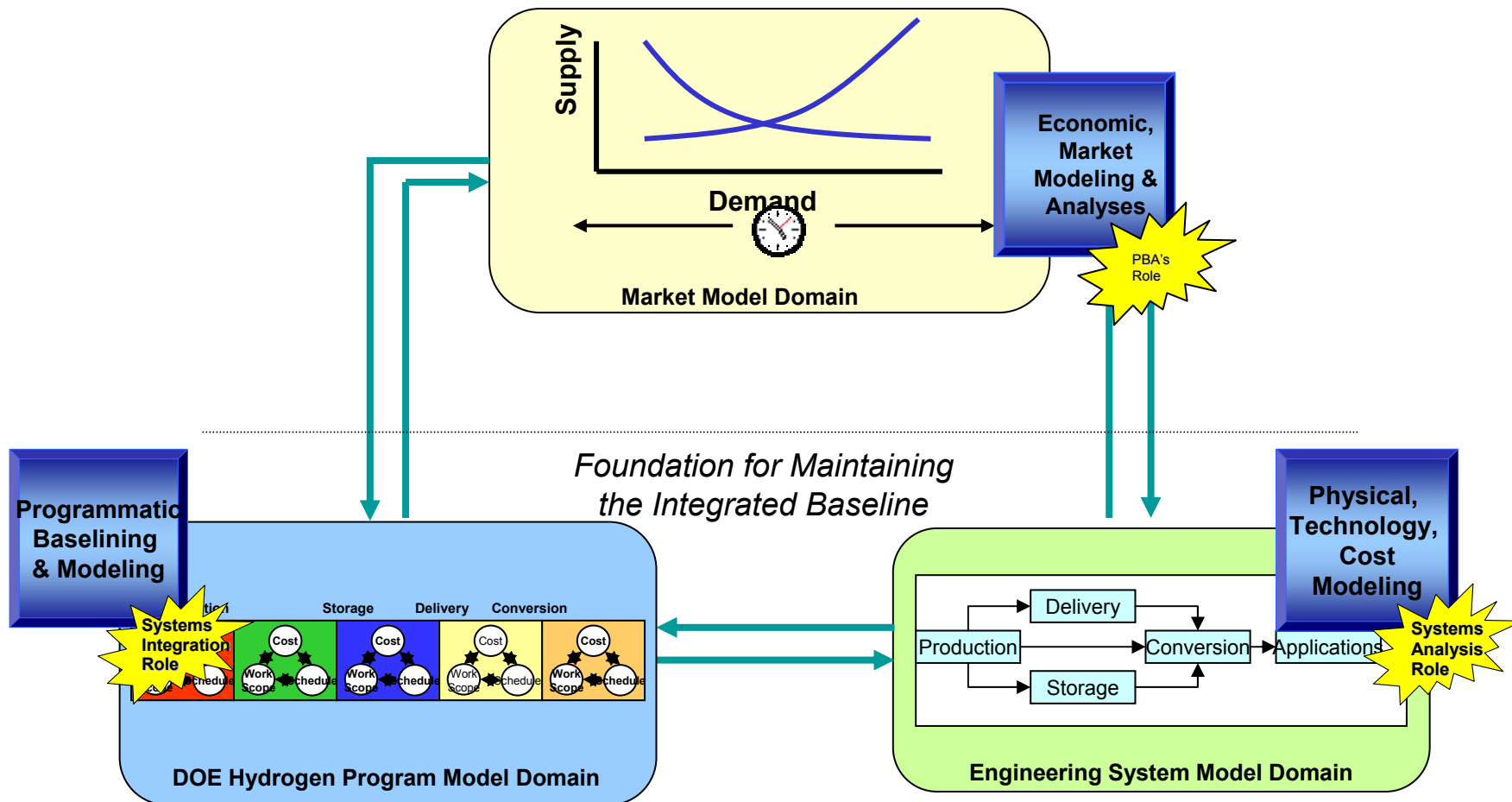
Questions





- **Responses to previous year reviewers' comments**
 - Not reviewed previously
- **Hydrogen safety**
 - This is a modeling effort. There are no hydrogen hazards directly associated with it.
- **Publications and presentations**
 - There have been no publications on this work.
 - There have been no presentations outside the HFCIT program

Role in EERE Modeling Domain



- **Macro-system model will simulate system performance and enable evaluation of components/interfaces from system level perspective**