HyDS Modeling Environment
Keith Parks
National Renewable Energy Lab
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Overview

Timeline
- Start – May 2005
- Finish – October 2006
- 80% Complete

Budget
- Funding for FY06
  - 100K

Barriers
- Infrastructure Analysis
- Scenario Modeling
- System Analysis

Partners
- Worked with DTI, ORNL, and ANL
Objectives

- GIS-Based, Supply-Side Transition Analysis
  - Cost out pathway for cities within a region
  - Determine the infrastructure layout for different production/delivery choices
  - Consider electricity sector impacts and contributions to hydrogen economy
Approach

**INPUTS + OPTIMIZATION = OUTPUTS**

- **GIS**
- **H2A**
  - Scenario Model
  - Production
- **Natural Gas Cost**
- **Hydrogen Pathway Optimizer (Go Pipes!)**
- **HyDS**
  - Regional Supply Curve
  - Regional Network Map
  - Electricity Sector Costs
  - Electricity Based H₂ Costs
- **NG Feedback**

- **Detail to City Level (Population, Vehicles, Area)**
- **Existing H₂ Facilities**

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**Region Supply Curve for Chicago/Detroit Region**

- **Coal Gasification**
- **Distributed SMR**

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NRAL National Renewable Energy Laboratory
Inputs – H2A Production

- Production is the sum of fixed and variable costs
- Costs change with fuel forecast and H2A learning assumptions
- Min/Max Capacities enforced

Production Technologies
- Central/Distributed SMR
- Central Coal gasification
- Central Biomass gasification
- Wind/electrolysis
- Distributed electrolysis
- Nuclear

Dynamic Link to H2A Production Model
- Updates Fuel Costs
- Reruns H2A Cash Flow
- Automatically Updates Costs
Inputs – H2A Scenario Model

• Derived equation for **each component** (e.g., liquefier, compressed truck, pipelines)
  – All components influenced primarily by demand or city area, or both
  – Accuracy within $0.05 for most scenarios ($R^2$ of >99% for all components)
  – Equation does less well at extremes
    • at very low penetrations in small cities
    • very large cities at high penetrations

• Worked with DTI, ORNL, and ANL in Using H2A Scenario Model
Pathway Optimization

\[
\text{Cost} = f(\text{Demand}) + f(\text{Distance}) + f(\text{Demand, Area})
\]
Putting It Together…

- Modified Minimum Spanning Tree Algorithm
- Considers Production and Transportation Economy of Scale
- GIS Output – Intuitive Results
Regional Supply Curve

• Delivered Cost
• Color Coded by Production Type

*2026 w/ $12.00 NG; 15% Penetration
Natural Gas Elasticity

- Based on NEMS Forecasts
- Consistency between all components
What Can We Answer?

- What are the hydrogen delivered costs within a region?
  - Least cost or for a particular technology
  - Quickly compares/contrasts technologies

- How does development of a hydrogen economy effect the capacity expansion of the electricity sector?

![Liquid Delivery Region Supply Curve for Chicago/Detroit Region*](image)

![Pipeline Delivery Region Supply Curve for Chicago/Detroit Region*](image)

*2026 w/ $12.00 NG, 15% Penetration
Liquid Delivery Layout
Pipeline Delivery Layout
Larger Type for Delivery Scenarios

Liquid Delivery

Pipeline Delivery

Region Supply Curve for Chicago/Detroit Region*

- Coal Gasification
- Distributed SMR

*2026 w/ $12.00 NG, 15% Penetration
Future Work

- Running scenarios for Final Draft FY06 Report due July 2006
  - AEO 2006 Feedstock Price Scenario
  - Natural Gas Price Sensitivity
  - Demand Sensitivity
  - Assumptions and Findings
Summary of the Strengths/Weaknesses

• Strengths
  – Spatial; addresses urban/rural interface
  – Consistency through integration of models and price paths
  – Fast, simple operation for static scenarios
  – Electricity sector integration

• Weaknesses
  – No Foresight/Hindsight (ie Static Model)
  – No demand side component – must be entered
Publications and Presentations

FPITT Review - Oct 2005
Annual Review 2005 (HyDS)
Annual Review 2006
Critical Assumptions and Issues

• Inherits all H2A Production and Scenario Model Assumptions
• Uses the “Urbanized Area” definition for city boundaries
• Competes three production technologies at a time
• Always competes distributed vs central