Hydrogen Production Infrastructure Options Analysis

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Project ID # ANP2

This presentation does not contain any proprietary or confidential information

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Overview

Timeline

- Start: ~May 2005
- End: February 2007
- Project has not commenced

Budget

- Total project funding: $749,446.00
- FY05: $192,926.00
- FY06: $427,309.00
- FY07: $129,211.00

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Overview

Barriers

- Lack of prioritized list of analyses for appropriate and timely recommendations.
- Stove-piped/Siloed Analytical Capabilities.
- Lack of understanding of the transition of a hydrocarbon-based economy to a hydrogen-based economy.

Partners

- Sentech, Inc.
- Professor Carraway
  - Univ. of Virginia, Darden School of Business
- H2Gen Innovations
- ChevronTexaco
- Teledyne Energy Services

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Project Objective

The program objective is a better understanding of how a hydrogen production infrastructure for H_2 FC/ICE vehicles might develop in the US.

- Development scenarios over time
- Determine which factors will drive it
- The role of externalities such as policy and technology advancement

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Approach

- Development of a time-based, computational dynamic model of H_2 production in the continental US.
- Use model and other methods to understand how a H_2 production infrastructure will develop over time, the factors that will drive it, and the role of externalities, such as policy and technology.
- This model will use consistent financial & technological assumptions to evaluate H_2 production & delivery costs dynamically (as opposed to statically) with changing demand and utilization.

Differentiating Features

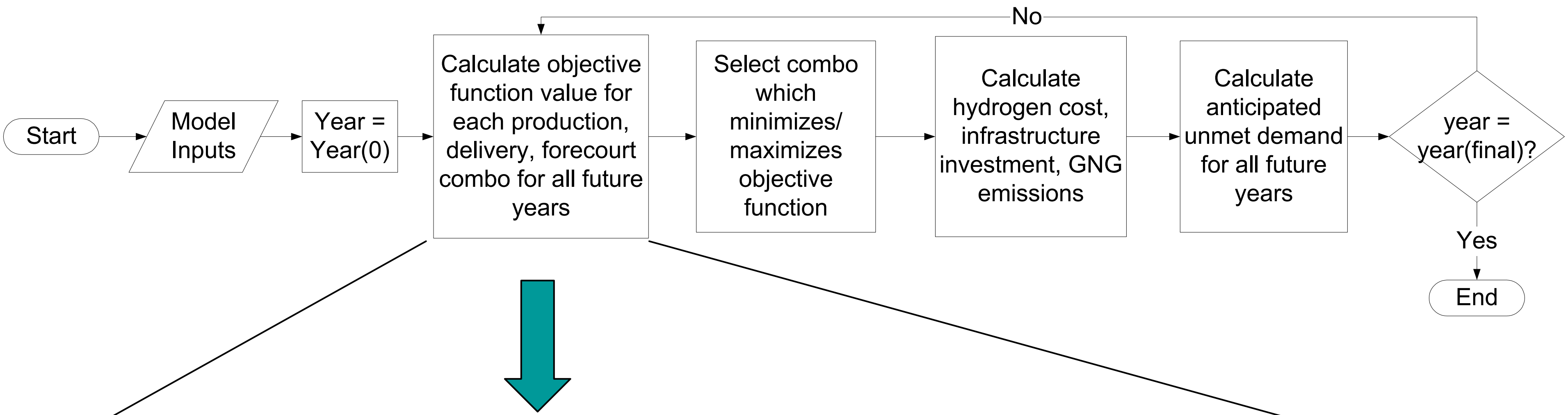
The model will:

- Allow H_2 demand foresight for planning infrastructure
- Assess H_2 production facility displacement due to technological and demand changes in time (stranded assets)
- Allow dynamic calculation of hydrogen costs, including the effects of changing infrastructure utilization

Tasks

- **Creation of Cost and Performance Database:** Develop a database of relevant information using clearly defined and rational technology and financial assumptions.
- **Baseline Production Transition Analysis:** Generate a baseline hydrogen infrastructure buildup scenario using database inputs and applying methods of constrained economic optimization
- **Sensitivity Analysis, and In-depth Examinations:** Perform sensitivity analyses by varying model parameters such as hydrogen demand, costs, greenhouse gas emission penalties, technological developments, and political and societal decisions.
- **Opportunities and Considerations Summary:** Identify the implications of hydrogen production infrastructure development and assess the potential for research, development, and policy prescription to achieve desirable results.

Dynamic Model Flow Diagram



- The objective function is the key driving element of the model.
- The exact definition will be formulated during Tasks 1 and 2.
- For planning purposes, the nominal objective function is the delivered cost of hydrogen [$/kg] where ‘other costs’ include taxes, GHG emissions, renewable fuel credits and infrastructure permits.

cost of hydrogen [$/kg] =

production cost + delivery cost + forecourt cost + other costs

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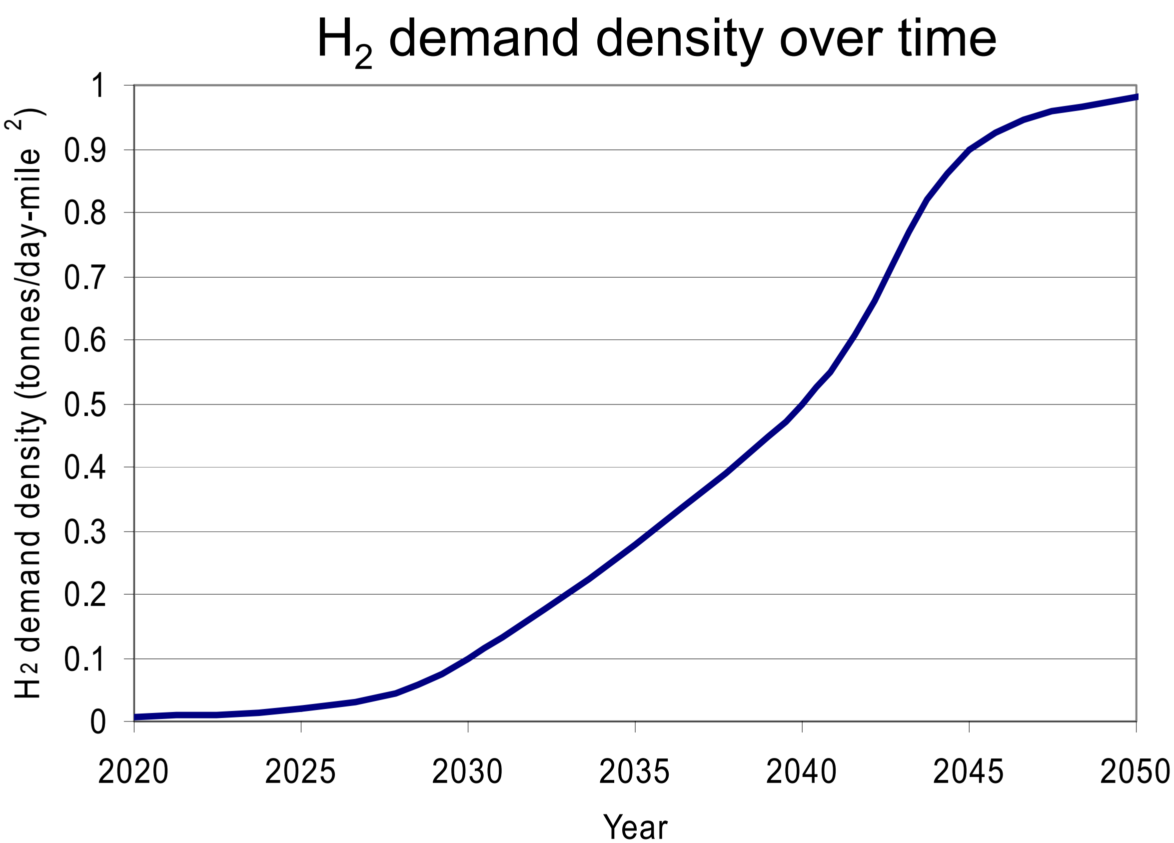
Dynamic model example

Input Model Parameters

- Assume H_2 demand profile
- Assume minimum interstation distance
  - Interstate scenario: 25 miles
- Allow 10-year foresight for planning infrastructure



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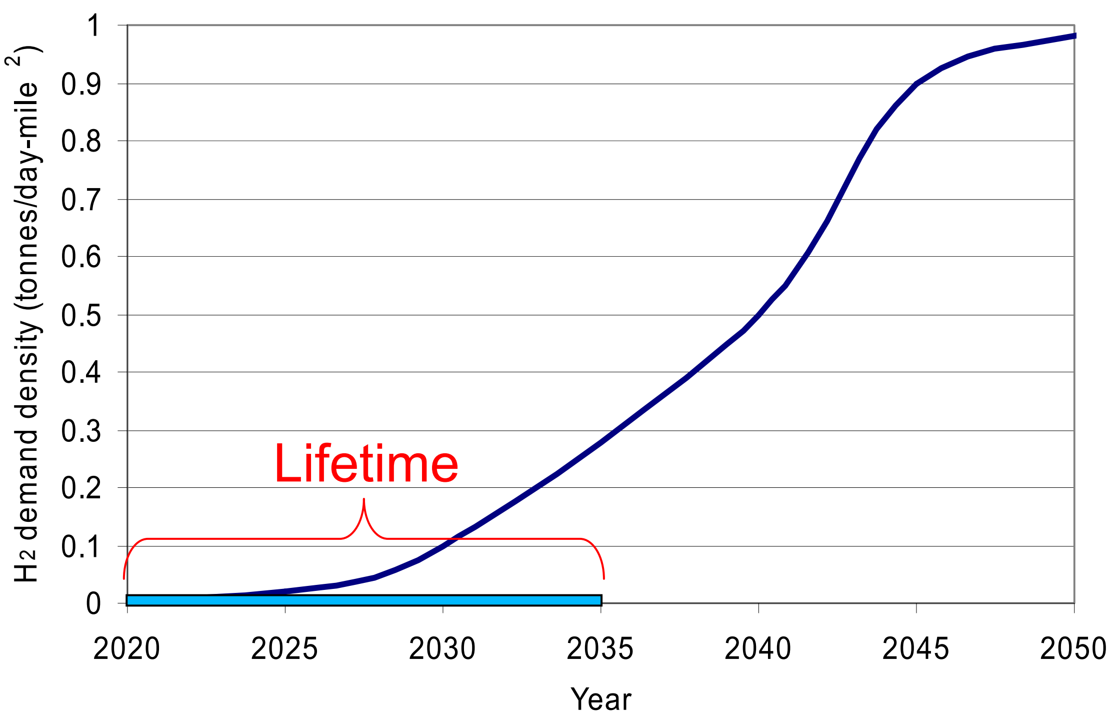
Dynamic model example

Evaluate all potential pathways to provide expected H_2 demand for next x years and select best option.

- Year 2020: Evaluating NPV for all possible investments to meet demand results in

  4 production/delivery combinations
  x 10 capacity factors (2020 – 2029)

  40 NPV calculations
- Select investment which produces the lowest cost of hydrogen
  - Solution: 1x HFA's to meet 2020 demand
- Production facility lifetime provides future capacity



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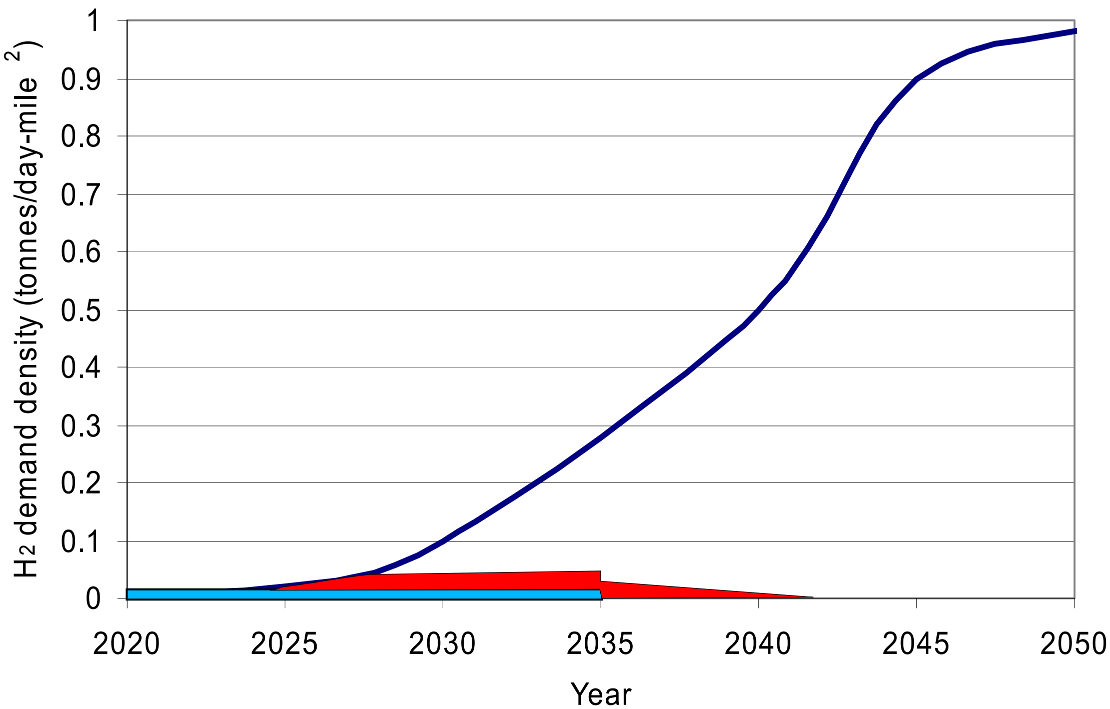
Dynamic model example

An opportunity to increase installed capacity occurs yearly.

- Year 2021: Evaluate NPV for all possible investments to meet remaining demand (total demand minus installed capacity).
- Select investment which produces the lowest cost of hydrogen
  - Solution: Install 1x HFA to meet 2021 demand minus 2020 demand.
- Years 2022 thru 2027:
  - Solution: Install 1x HFA's for current net demand each year.



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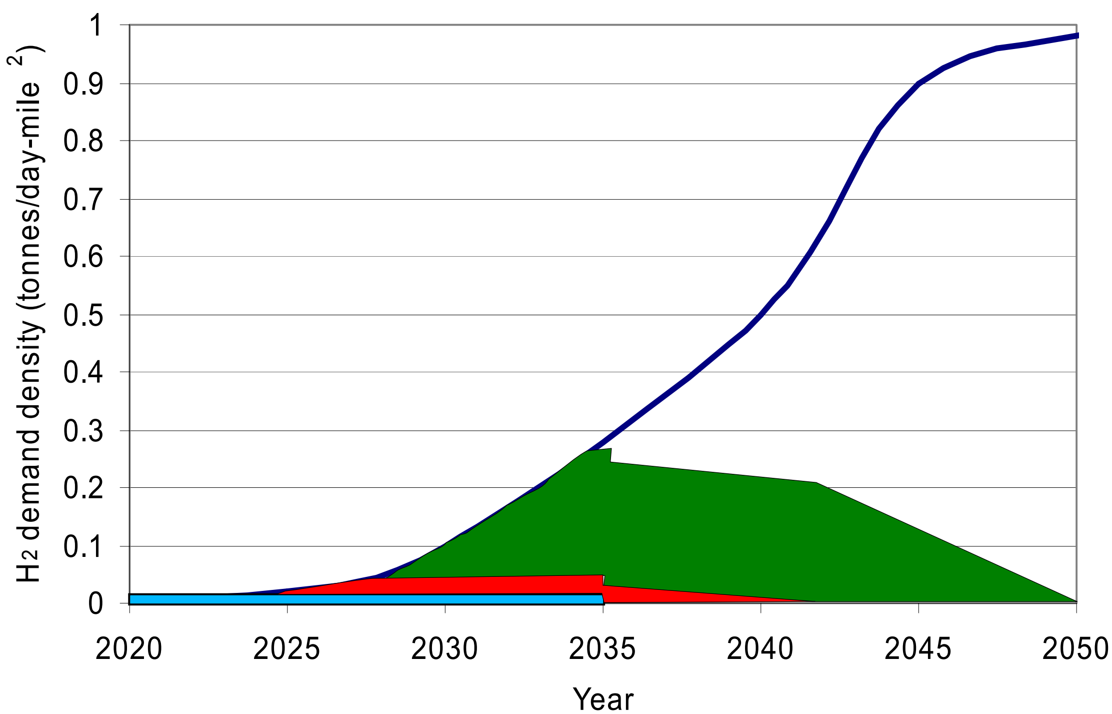
Dynamic model example

In years 2028 – 2034 rate of demand increases and the best option becomes larger production facilities.

- Year 2028: Evaluate NPV for all possible investments to meet remaining demand
- Select investment which produces the lowest cost of hydrogen
  - Solution: 15x HFA's to meet net 2028 demand
- Years 2029 thru 2034:
  - Solution: Install 15x HFA's to meet current net demand each year



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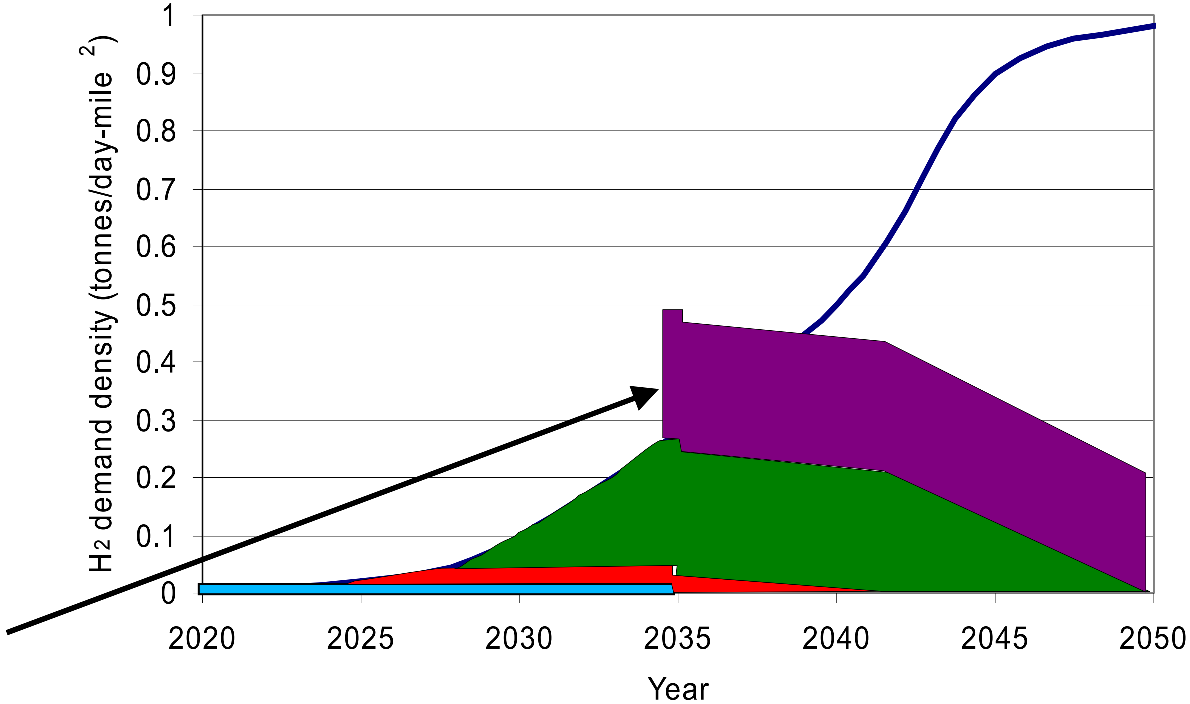
Dynamic model example

As installed capacity decreases, large central facilities temporarily operating at decreased capacity become viable solutions.

- Year 2035: Evaluate NPV for all possible investments to meet remaining demand
- Select investment which produces the lowest cost of hydrogen
  - Solution: Install centralized SMR with pipeline delivery for 2040 demand.
  - Runs at decreased capacity for first 4 years
- SMR production facility has a 30-year lifetime



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Technical Accomplishments/ Progress/Results

Project has not yet been initiated.

Future Work – FY05

Task 1 - Creation of Cost and Performance Database

- Develop list of parameters which describe H_2 production system economics and performance for each production method.
- Research and quantify parameters
- Quantify effects of politics on cost, performance and technology curves
- Define Baseline Model Case

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Publications and Presentations

None to date.

Hydrogen Safety

This project is an analytical study and therefore has no significant hydrogen hazard associated with it.