Assessment of Power-to-gas Towards Multiple Production Pathways and Grid Applications

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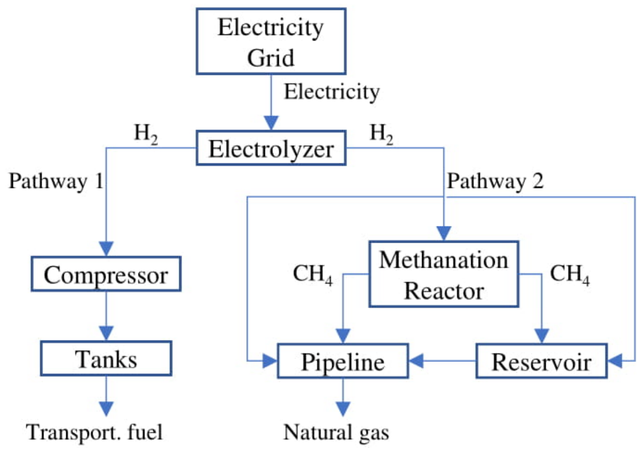
PROJECT OVERVIEW

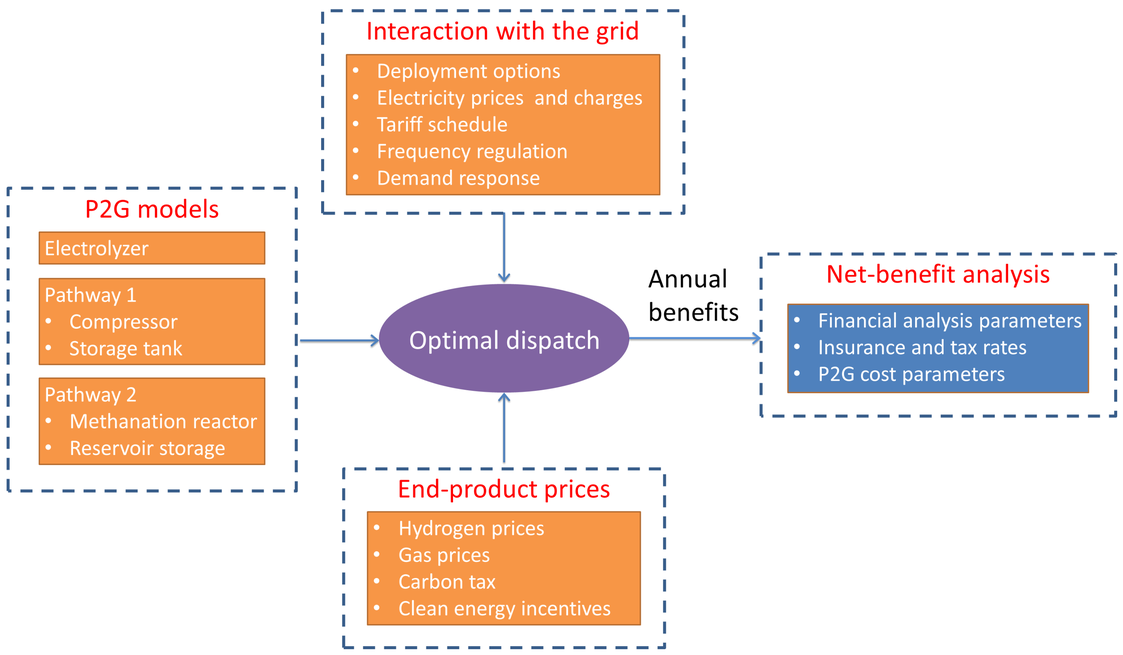
This project develops a techno-economic assessment framework and a web-based tool for a power-to-gas (P2G) system in two common pathways for gas production and transport, while providing ancillary services and demand response, considering potential clean energy incentives. Models are developed to capture operation associated with the production, compression, storage, and methanation of hydrogen as well as different grid services from a P2G plant in an economic assessment. An optimization problem is formulated to determine the optimal operation of the P2G plant with an hourly step over a year to maximize the annual benefits, and thereby evaluate the economic performance of a P2G system.



METHODOLOGY AND INNOVATION

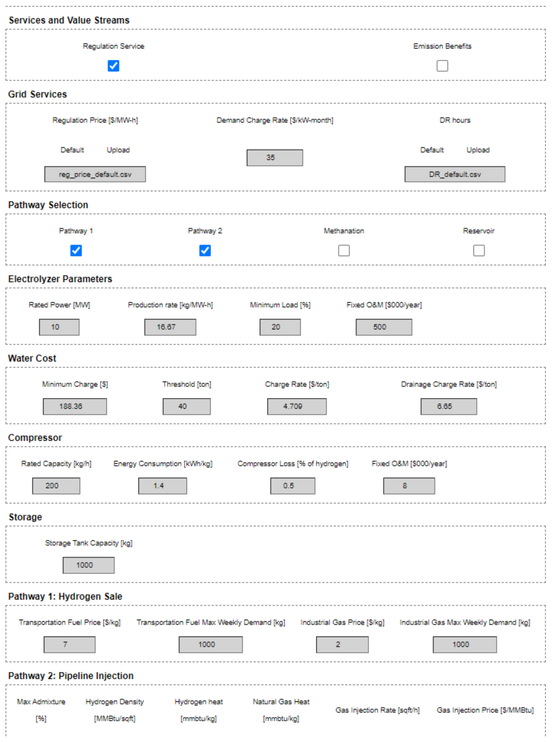
- ❑ We developed an innovative techno-economic assessment framework to capture multiple value streams from end-product sales, fuel cost savings, grid services, and potential clean energy incentives, considering their trade-offs..
- ❑ We modeled the technical and economic characteristics of individual P2G components, including electrolyzer, compressor, storage tank, methanation reactor, underground reservoir, and pipeline injection.
- ❑ Applying optimization tricks, we developed a mixed-integer linear programming formulation to determine the optimal operation of the P2G plant and distribution of produced hydrogen along two pathways with an hourly step over a year to maximize the economic benefits.
- ❑ We proposed heuristic relaxation methods to speed up the solution process.
- ❑ We performed a comprehensive financial analysis to evaluate the economic performance of a P2G system.
- ❑ We developed a web-based P2G evaluation tool with a user-friendly interface..

OPTIMAL DISPATCH AND ECONOMIC ASSESSMENT



P2G EVALUATION TOOL

Accessible at https://eset.pnnl.gov/ . Part of Input (left) and Output (right) screenshot :



SELECTED EVALUATION RESULTS

We evaluated the economic benefits of a 10 MW ITM Power P2G unit sited in the Holyoke Gas and Electric service territory in 11 representative cases with 82 runs in total considering different combinations of electricity prices, reservoir availability, and storage tank capacity.

Case #	Description (changes from case 3)	20-Year PV Benefits ($m)	ROI
2	Hydrogen as transportation fuel + natural gas injection	21.6-22.4	0.25-0.28
3*	Case2 + Frequency regulation	23.2-29.0	0.37-0.54
5b	Tripling transportation fuel demand	25.8-29.9	0.82-0.88
8a	Carbon tax at $50/ton	29.4-39.9	0.45-0.71
10b	Case 5 with a 5 MW P2G unit	16.8-18.1	1.19-1.21

- ❑ Hydrogen sale as a transportation fuel is a key driver of revenue.
- ❑ A reservoir helps to take advantage of low electricity prices for hydrogen production and high gas prices for sale.
- ❑ Regulation and demand response services significant increase P2G operating hours and benefits.
- ❑ Clean energy incentives could be important value streams.
- ❑ Downsizing the P2G unit lowers capital costs considerably, yielding an ROI exceeding 1.0.

CONCLUSIONS

- ❑ The proposed method effectively evaluates P2G benefits from multiple value streams by optimally dispatching the P2G system.
- ❑ Grid services and clean energy incentives are important value steams in addition to hydrogen sale as a transportation fuel.
- ❑ Optimal sizing is critical for a P2G project to be financially viable.

U.S. DEPARTMENT OF ENERGY

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