LCRI LOW-CARBON RESOURCES INITIATIVE

EPRI

FACT SHEET

HyRAM+

Hydrogen Plus Other Alternative Fuels Risk Assessment Models

HyRAM+
Hydrogen Plus Other Alternative Fuels Risk Assessment Models

INTRODUCTION

Hydrogen's unique properties—its small molecular size, high flammability, and rapid dispersal—create distinctive safety challenges. The potential for leaks, flame jetting, and high ignition probabilities necessitates robust tools to assess and mitigate risks. Understanding these risks and their impacts requires advanced physics calculations and quantitative risk assessment (QRA).

WHAT IS HyRAM+?

HyRAM+ is a software toolkit developed by Sandia National Laboratories to enable accurate risk assessments of hydrogen and alternative fuel systems. Initially developed to support safety studies in fueling stations and industrial applications, HyRAM+ has evolved through multiple versions to meet the growing complexity of hydrogen infrastructure. The development of HyRAM+ has been funded by the U.S. Department of Energy and supported by experts in hydrogen safety and engineering.

FUNCTIONALITY AND USE CASES

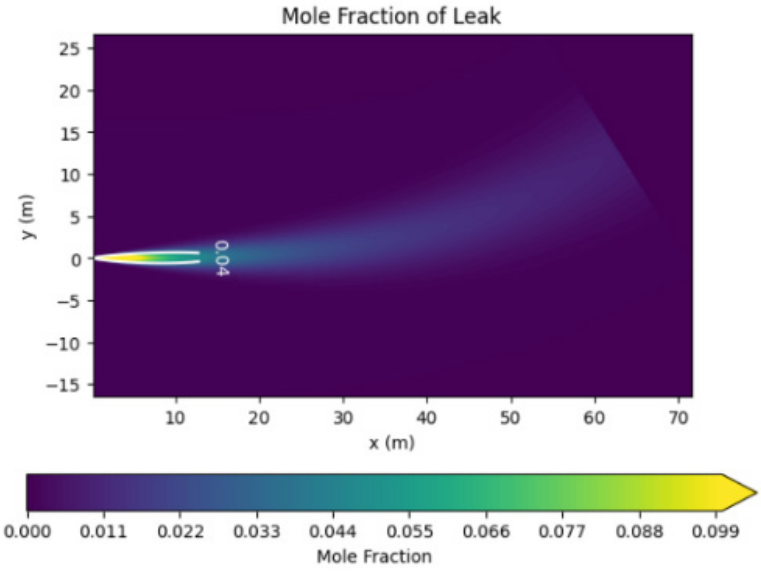
HyRAM+ integrates deterministic and probabilistic models to quantify accident scenarios, assess leak probabilities, predict physical effects (e.g., jet flames and explosions), and evaluate the impact on structures and individuals. The software provides essential capabilities for:

- **QRA**: *Analyzing potential failure scenarios and calculating risk metrics, such as the probability of ignition and potential loss of life.*
- **Plume Dispersion Modeling**: *Simulating the dispersion of hydrogen gas and evaluating safe distances and sensor placement.*
- **Scenario Analysis**: *Identifying the most impactful risk factors and visualizing event sequences.*

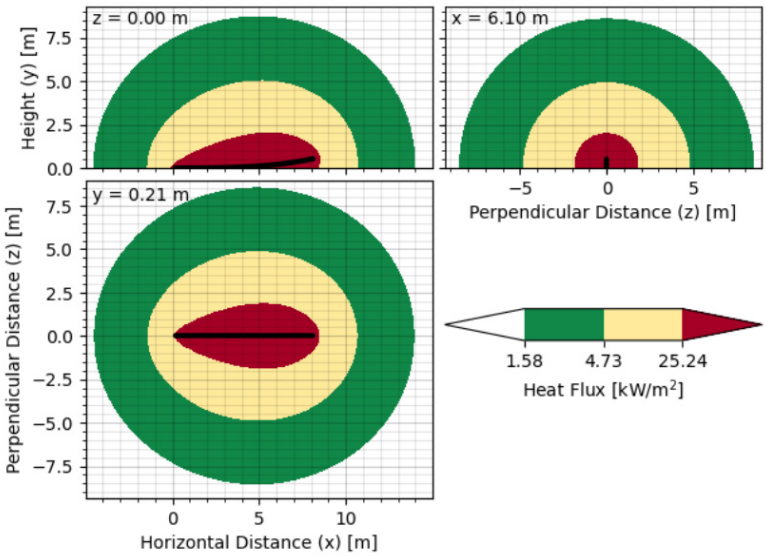
HyRAM+ is particularly valuable for industries using hydrogen as a fuel or energy carrier, including transportation, industrial processing, and energy storage.

EXAMPLE HyRAM+ OUTPUTS

Plume Dispersion Model



Jet Flame Radiative Heat Flux Map



LCRI PROJECT EXAMPLE

EPRI utilized HyRAM+ in the development of intentional hydrogen release experiments. This project applied HyRAM+ to:

1. *Calculate optimal vertical sensor placement as a function of line pressure and flow conditions.*
2. *Assess safety under experimental conditions, ensuring that pressures, flow rates, and apparatus configurations maintained low ignition probabilities.*

This effort exemplifies how HyRAM+ supports rigorous safety protocols and innovation within LCRI projects.

CONCLUSION

EPRI has worked closely with HyRAM+'s developers at Sandia to provide feedback and insights from real-world applications. This ongoing collaboration enhances HyRAM+'s usability and effectiveness, aligning with EPRI's commitment to safety in the deployment of low-carbon fuels. Continued work will include further validation and potential software updates to keep pace with the evolving needs of hydrogen safety.

DISCLAIMER OF WARRANTIES AND LIMITATION OF LIABILITIES

THIS DOCUMENT WAS PREPARED BY THE ORGANIZATION(S) NAMED BELOW AS AN ACCOUNT OF WORK SPONSORED OR COSPONSORED BY THE ELECTRIC POWER RESEARCH INSTITUTE, INC. (EPRI). NEITHER EPRI, ANY MEMBER OF EPRI, ANY COSPONSOR, THE ORGANIZATION(S) BELOW, NOR ANY PERSON ACTING ON BEHALF OF ANY OF THEM:

(A) MAKES ANY WARRANTY OR REPRESENTATION WHATSOEVER, EXPRESS OR IMPLIED, (I) WITH RESPECT TO THE USE OF ANY INFORMATION, APPARATUS, METHOD, PROCESS, OR SIMILAR ITEM DISCLOSED IN THIS DOCUMENT, INCLUDING MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, OR (II) THAT SUCH USE DOES NOT INFRINGE ON OR INTERFERE WITH PRIVATELY OWNED RIGHTS, INCLUDING ANY PARTY'S INTELLECTUAL PROPERTY, OR (III) THAT THIS DOCUMENT IS SUITABLE TO ANY PARTICULAR USER'S CIRCUMSTANCE; OR

(B) ASSUMES RESPONSIBILITY FOR ANY DAMAGES OR OTHER LIABILITY WHATSOEVER (INCLUDING ANY CONSEQUENTIAL DAMAGES, EVEN IF EPRI OR ANY EPRI REPRESENTATIVE HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES) RESULTING FROM YOUR SELECTION OR USE OF THIS DOCUMENT OR ANY INFORMATION, APPARATUS, METHOD, PROCESS, OR SIMILAR ITEM DISCLOSED IN THIS DOCUMENT.

REFERENCE HEREIN TO ANY SPECIFIC COMMERCIAL PRODUCT, PROCESS, OR SERVICE BY ITS TRADE NAME, TRADEMARK, MANUFACTURER, OR OTHERWISE, DOES NOT NECESSARILY CONSTITUTE OR IMPLY ITS ENDORSEMENT, RECOMMENDATION, OR FAVORING BY EPRI.

THIS REPORT WAS PREPARED BY EPRI.

About EPRI

Founded in 1972, EPRI is the world's preeminent independent, non-profit energy research and development organization, with offices around the world. EPRI's trusted experts collaborate with more than 450 companies in 45 countries, driving innovation to ensure the public has clean, safe, reliable, affordable, and equitable access to electricity across the globe. Together, we are shaping the future of energy.

EPRI CONTACT

ALEX GUPTA
Low-Carbon Fuel Safety Specialist
505.709.5787, algupta@epri.com

For more information, contact:

EPRI Customer Assistance Center
800.313.3774 • askepri@epri.com

3002031855 **March 2025**

EPRI
3420 Hillview Avenue, Palo Alto, California 94304-1338 USA • 650.855.2121 • www.epri.com